SECRET
UK EYES B

Copy No. 66

CENTRAL REGISTRY
Library No: B0341
F102 No: MI: 528
Location: CAB X 'B'
This document is issued on your signature. It should be returned as soon as possible after use.

AIR HISTORICAL BRANCH
CATALOGUE
VB/231/3
NUMBER
R.A.F.

AIR WARFARE CENTRE

5895
MINISTRY OF DEFENCE
AIR HISTORICAL BRANCH
(RAF)
29/9/05

TORNADO GR 1

TACTICS MANUAL

AWC/LRMP/OAE
(A/12) - MI: 940
23 NOV 1994
HQ 18 GROUP

CTTO/6/11/Air

SECRET
UK EYES B

JULY 1993
AL 2

HISTORICAL BRANCH
CATALOGUE
IVB/231/3
NUMBER
R. A. F.

AIR WARFARE CENTRE

Boscombe Down, Salisbury, Wiltshire, SP4 OJF

Amesbury (01980) 663075 (GPTN 95431) Ext 3075

Secure Fax Ext 3298 Insecure Fax Ext 3060

See Distribution

Our reference: AWC/BD/6/11/Air

Date: 1 May 95

AWC TORNADO GR1 TACTICS MANUAL 3RD ED - AMENDMENT LIST 3

Reference: A. CTTO/6/11/Air dated Jul 93

1.(R) The Tornado GR1 Tactics Manual - 3rd Edition was issued under cover of Reference A. The Manual has been revised; the changes are effected by Amendment List No 3 and your copy is enclosed. The main change resulting from AL 3 is the introduction of Section 10 - ALARM Operations.

2.(U) The Amendment should be incorporated in the Manual as follows:

a. **Prelim Pages**. Remove Distribution List (Prelim Pages 7 to 10 (2 sheets)) and replace with new Distribution List (2 sheets).

b. **Section 10**. Amendment action involves the insertion of a complete Section 10. Initially remove the existing Section 10 Marker card, and pages 10-1-1/10-1-2 (total 2 sheets). Then insert the following pages in order:

(1) New Section 10 Marker Card.

(2) Chapter 1, pages 10-1-1/10-1-2 (total one sheet).

(3) Chapter 2, pages 10-2-1 to 10-2-4 (total 2 sheets).

(4) Chapter 3 and Annex A, pages 10-3-1 to 10-3A-2 (total 3 sheets).

c. **List of Effective Pages**. Remove Pages LEP 1 to LEP 8 (4 sheets) and insert new LEP, pages LEP 1 to LEP 10 (5 sheets).

d. **Manuscript Amendments**. Carry out the following manuscript amendment, annotating the bottom outer corner of the relevant page "AL 3 (MS)" in lieu of "AL2":

(1) **Section 11, Chapter 2, Annex G,** the second page of the Annex (Intentionally Blank) is incorrectly numbered, change to read "11-2G-2".

AWC/NOEU/OAE
MO: 156/05
28 JUL 2005
JOINT HQ (RAF)

AWC/LRMP/OAE
MC: COU 254
19 MAY 1995
HQ 18 G P

AWC/NOEU/OAE
Reviewed
2[illegible] NOV [illegible]
JOINT HQ (RAF)

AWC/NOEU/OAE
REVIEWED BY TCS/WPNS
22 FEB [illegible]
JOINT HQ (RAF)

e. **Administrative Action**. Record the incorporation of the Amendment by completing the entries on the Amendment Record Sheet at Prelim Page 11. An independent check is to be carried out iaw AP 3086 (or equivalent Security Manual) and the Record Sheet completed. The pages removed by AL 3 (8 sheets) are to destroyed locally (iaw AP 3086). Finally, the Amendment Instructions (ie this letter) are to be inserted in the Manual immediately following Prelim Page 16. AL instructions for AL 2 are to be removed and destroyed.

3.(U) Acknowledgement action is to be effected by the completion (and return) of the enclosed MOD F24.

[redacted]

Enclosures:

1. Amendment List No 3 to AWC Tornado GR1 Tactics Manual - 3rd Ed, replacement pages totalling 14 sheets.

2. MOD F24.

Distribution:

Distribution as listed on Prelim Pages 7 to 9 of the Tornado GR1 Tactics Manual to AL3 (forwarded under cover of this letter).

LETTER OF PROMULGATION

Letter of Promulgation by HQSTC to be issued

CTTO (LRMP)
ML/528
24 AUG 1993
HQ 18 GROUP

HQ No. 18 GROUP
RAF NORTHWOOD
[illegible]
24 AUG 1993
1852

C.T.T.O.
MAIL OUT F102 No. 2451
20 AUG 1993
BOSCOMBE DOWN

INTENTIONALLY BLANK

FOREWORD

1. The aim of this Manual is to present up-to-date tactical information and guidance to those directly concerned with the operation of the Tornado GR1. The Manual is complementary to the Tornado GR1 Aircrew Manuals, SOPs and the Aircraft Operating Data Manuals.

2. The demise of the Warsaw Pact and the USSR has raised many questions as to the future threat to United Kingdom interests and to NATO. Where deterrence is or has been effective only the unexpected occurs and the Falklands Campaign, the Gulf War and Bosnia are indicators to the future use of United Kingdom armed forces. It therefore follows that any organization intending to record tactics must be aware of the dangers - how many times have we prepared to fight the last war? Nevertheless, there is an equal and opposite pitfall - re-inventing the wheel - when hard won lessons and corporate knowledge are ignored. In an era of uncertainty and ever tightening budgets we cannot afford either. Thus, this Manual concentrates on the specifics of the tactical level of war, from wings/squadrons down to individual crew/aircraft, leaving the more uncertain operational (campaign) and strategic levels of war to those with a crystal ball.

3. The tactics described in the Manual are techniques and not mandatory orders requiring rigid interpretation. Nevertheless, they provide the most authoritative advice available and are based on comprehensive studies, trials and the latest intelligence information. The advice given and the tactics suggested are intended for use in war and should influence peacetime training but in no way do they invalidate peacetime training regulations or replace existing orders or instructions.

4. Threat information is essentially that obtained from up-to-date intelligence analysis, with the emphasis being on whether the influence has been Western or Soviet. The adage "It is difficult to teach an old dog new tricks" will apply for some time to come when considering the relevant threat. For convenience the term "Soviet" is used generically to describe equipment designed or produced by the USSR and the "modus operandi" used by them in the past.

5. To be of continuing use the Manual must be kept up-to-date and to this end comments from individuals and units are required. To ensure that changes to procedures and tactics are notified to users without delay the information will be disseminated by means of Tactical Memoranda (Tac Memos). Tac Memos will be printed on Yellow paper to indicate their status and will be retained in the Manual until incorporated, in the appropriate Chapters, by formal amendment action. Amendments will be issued at regular intervals following a review conference to which user formations will be invited. Correspondence concerning improvements to the Manual is welcomed and should be sent direct to Air Warfare Centre (for the attention of SA Tor P/N), with copies to HQ 1 Gp/HQ 2 Gp (as appropriate).

A.W.C.
MAIL OU 2870
18 NOV 1994
BOSCOMBE DOWN

J G Lumsden
Air Cdre
Comdt
Air Warfare Centre

10 Nov 94

INTENTIONALLY BLANK

CONTENTS

Section 1 Introduction

2 Terrain Following

3 The Threat

4 EW

5 Mission Planning

6 Sortie Tactics

7 Strike Phase

8 Maritime

9 Medium Level and LGB Procedures

10 ALARM Operations

11 Reconnaissance

12 Glossary

INTENTIONALLY BLANK

DISTRIBUTION LIST

	Copy No
MOD (Air)	
D Air Plans	1
D Science (Air)	2
DD Air Off	4
OR 83(Air)	6
MOD (PE)	
Ops Syst Div FS (B) 2, DRA Bedford	8
HQ STC	
SO 2 J3 (Air)	9
HM Naval Base,Portsmouth	
RAFSO	12
OC 899 Naval Air Squadron, (Thru' CBO)	
RNAS Yeovilton,Ilchester, Somerset	13
HQ 1 Gp	
Wg Cdr Torn	15
Sqn Ldr Wpns/EW	16
No2 MHQ R Aux AF, Edinburgh	23
DTEO Boscombe Down	
OC RAF Handling Sqn	24
GARF, FJTS	25
DRA (Ae) Farnborough (Thru' Establishment Sy O)	
Information Centre (Q4 Building)	26
Systems Assessment Div (SA 1)	28
DOAC West Byfleet (Thru' Establishment Sy O)	29
GCHQ (for Head J 24 G)	30
MWDC (CBO), HMS Dolphin, Gosport	31
JMOTS (Director RAF)	33
HMS Dryad	
SMOPS(Thru' CBO HMS Dryad)	35
HMS Dolphin	
F MWC (Thru' CBO)	60
HMS Illustrious (Thru' CBO for AWO (A))	37
HMS Invincible (Thru' CBO for AWO (A))	38
RAF Coningsby	
SIEWO	73

RAF Cottesmore	
TOCU Registry	40
OC TISMT	41
RAF Bruggen	
OC Ops Wg	42
OC IX Sqn	43
OC 14 Sqn	44
OC 17 Sqn	45
OC 31 Sqn	3 & 46
OC STANEVAL (Wpns)	47
OC MMF	69 & 74
RAF Kinloss (NFTC)	52
RAF Lossiemouth	
OC Ops Wg	53
OC 12 Sqn	57
OC 617 Sqn	58
OC XV(R) Sqn	51
OC STANEVAL (Wpns)	54
Mission Suppt Flt (WEWO)	68
RAF Marham	
OC Ops Wg	55
OC II (AC) Sqn	56
OC 13 Sqn	49
OC STANEVAL (Wpns)	59
IPS (Int Planning Sqn)	71
British Aerospace plc, thru' Company Sy O	
Stevenage Bus'ness Develop Mngr [redacted]	62
British Aerospace plc, thru' Company Sy O	
Warton, (A&AEE Trials Liaison Flt Ops, W27D)	27
Internal:	
AWC - OD&T (RAF College Cranwell)	39
AWC - OAE (Bentley Priory)	10
AWC - AGW OEU (RAF Valley)	50
Library	63
SAOEU	64
SA Tor P	65
LRMP Cell	66
WMCC2	70
EW1	34
TMC (Master Copy)	67
Spares	17, 32, 72 & 75

AMENDMENT RECORD SHEET

1. To record the incorporation of an Amendment List (AL) in this publication:

    a. Insert the date of issue of the AL (ie date of covering letter)
    b. Sign against appropriate AL No..
    c. Insert name in BLOCK capitals and date of incorporation.

2. After the Amendment has been inserted, and before any superseded pages are destroyed, an independent check is to be made to ensure it has been incorporated correctly. The check is also to include a page check against the list of contents (List of Effective Pages at end of document). The independent checker is then to record this check on the Amendment Sheet by:

    a. Signing against the appropriate AL No..
    b Inserting name in BLOCK capitals and date of check.

3. The latest Amendment Instructions (ie Covering Letter) should be inserted at the end of the Prelim Pages Section.

4. Note that a separate sheet is used for recording the insertion/deletion of Tactics Memoranda.

Amendment List		Amendment Incorporated by			Independent Check by		
No	Date	Signature	Name /Rank	Date	Signature	Name/Rank	Date
1	3 NOV 93	[redacted]	[redacted]	16 NOV 93			
2	10 NOV 94	[redacted]	[redacted]	31 JAN 95	[redacted]	[redacted]	2/3/95
3	1 MAY 95	[redacted]	[redacted]	23 MAY 95	[redacted]	[redacted]	5/6/95
4							
5							
6							
7							
8							

TAC MEMO 1 (MS) [redacted] 14 MAY 96 – see page 13.
~~TAC MEMO 2~~

9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

TACTICS MEMORANDA STATUS RECORD

1. Tornado GR1 Tactics Manual - Tactics Memoranda (Tac Memo) will be issued as required for essential, but advance information, before the formal issue of an Amendment List change. They will be printed on yellow paper to emphasise their status. When information is incorporated in the Manual by amendment action the Tac Memo will be withdrawn by that AL and the record below updated accordingly.

2. The Tac Memos will be numbered chronologically and inserted in the Manual, adjacent to the relevant pages of the text, and the page numbering will reflect thatof the affected text; for example, 2-1-4AM/2-1-4BM (where the "M" indicates a Memo) facing page 2-1-4. To assist the reader, the relevant Section and Chapter of the main body of the Manual to which the Tac Memo refers will be recorded on the list below and an annotation "See Tac Memo No XX" inserted against the text on the appropriate page.

Tac Memo		Affected Pages	Incorporated by			Withdrawal Authorisation	
No	Date		Name	Date	Signature	Authority	Removed by/date:
1	MAY 96	-	[redacted]	14/5/96	See Page 11		
2	23/12/96	SECTION 6 CHAPTER 2	[redacted]	7/2/97	[redacted]		
3							
4							
5							
6							
7							
8							
9							
10							
11							

12							
13							
14							
15							
16							
17							
18							
19							
20							
21							

CUSTODIANS PAGE CHECK RECORD

Date Taken Over	Custodian	Date Page Checked	Signature
—	—	3 | MARCH | 95	[redacted]
12. MAY 95	[redacted]		

Note. All SECRET documents are required to to be page checked periodically and the check recorded on a "Custodians Page Check Record" (AP 3086, Ch 12, Para 1237).

INTENTIONALLY BLANK

Section 1

Introduction

CHAPTER 1 - INTRODUCTION

1.(R) Tornado GR1 entered RAF front-line service in 1982, initially for overland strike/attack operations and later as the Tornado GR1A in the recce role. In 1994, the Tornado GR1B will start to replace the Buccaneer in the ASUW role. Later in the decade all Tornado GR1/1A aircraft will be upgraded to GR4 standard after they have been through the Tornado Enhancement Programme (TEP). The characteristics and capabilities of the Tornado GR1/1A are significantly different from the aircraft it replaced, and design improvements permit all its roles to be carried out in almost all weathers by day and night at very low level and high speed. Throughout this Manual, Tornado GR1/1A/1B will be referred to as Tornado.

2.(C) Tornado has many features not possessed by other aircraft currently in RAF service; notably the variable geometry wing, the 'fly-by-wire' controls and the automatic terrain following (TF) system. The variable geometry wing is designed to optimize the aircraft's aerodynamic capabilities for a wide speed band ranging from airfield approach speeds in the order of 140 knots to supersonic speeds - although opportunities for employing very high speeds will be extremely limited. The 'fly-by-wire' flying control system is computer controlled resulting in less than normal variation in aircraft handling characteristics over the whole flight envelope. However, there is a marked change in aircraft performance between the light, low drag configurations and the heavy, high drag configurations. The automatic TF system processes signals from a dedicated terrain following radar (TFR) to generate commands to the aircraft autopilot and the system is designed to enable the aircraft to fly automatically down to 200 feet above obstacles.

3.(R) The heart of the aircraft's navigation/attack system is a digital main computer which accepts, monitors and distributes information from various sensors including an inertial platform, doppler radar, mapping radar and laser ranger. The system is designed to make blind attacks possible on both radar discrete and non-radar discrete targets, using offsets where necessary.

4.(C) Throughout the Manual, night and IMC are referred to as non-visual conditions; visual conditions are day/VMC only. In visual conditions, both visual attacks (pilot HUD aimed) and blind attacks (navigator radar aimed) can be executed but, at present, in non-visual conditions only blind attacks are possible. Because enemy tactics are likely to favour moving ground forces forward under cover of darkness or in poor weather, when they are generally less exposed to air attacks, it may prove more effective to employ Tornado predominantly in non-visual conditions whenever there is a choice, especially with the introduction of forward looking infra-red (FLIR) systems and night vision goggles (NVG). In these conditions, mobile defensive systems are denied the use of optical tracking devices and so their flexibility and effectiveness will be reduced. However, with the introduction of improved SAM systems, which is now taking place, the Tornado's vulnerability in non-visual conditions may be significantly increased.

5.(C) In NATO, air assets capable of prosecuting conventional attacks in non-visual conditions are at a premium and so Tornados are likely to be employed predominantly by night. Tasking in the ratio of about 2:1 in favour of night-time operations might therefore be expected.

6.(C) The tri-nationally agreed design requirement for small size imposed restrictions on the aircraft - notably the lack of an internal bomb bay and limited internal fuel capacity. Thus, except for the two 27mm guns, Tornado carries all weapons externally. In addition, external fuel tanks and ECM pods (Sky Shadow jamming pod and BOZ Chaff/IR flare pod) are mounted on underwing stations incurring drag and performance penalties. Although engine thrust at sea level almost doubles in full reheat compared to thrust at maximum dry power, fuel consumption is increased markedly and the aircraft is more vulnerable to IR guided missiles.

7.(R) **Content.** This Manual gives tactical advice designed to help aircrews exploit Tornado's strengths and minimize the effects of its limitations. Much of the advice has been taken from the results of CTTO trials and a list of these, together with their aims and the references of the relevant reports, is given at Annex A. In some areas the aircraft and its equipment do not yet have a full MOD (AFD) Release and therefore may not have been evaluated. Notwithstanding, advice is given, where possible, to prepare crews for situations that may occur in wartime.

8.(R) **Amendments.** This Manual will require frequent amendment; items of immediate operational interest that arise will be included in the Manual initially as Tactical Memos to ensure that such knowledge is available to all as soon as possible. The Tactical Memos will be printed on yellow paper so that they are readily identifiable and will be inserted in a Tactical Memo Section at the end of the document. The value of the Manual will depend largely upon the interest taken in it by frontline operators, and on their regular feed-back, review and suggestions (eg Tac Recs).

ANNEX A TO
SECTION 1, CHAPTER 1 OF
TORNADO GR1 TACTICS MANUAL

TORNADO GR1/1A TRIALS AND REPORTS

TRIALS

NOTE. ***The use of TRIALS codewords in isolation is usually RESTRICTED, but their use together with any text from which their meaning can be derived MUST be protected by the appropriate classification allocated to that codeword on issue; this has been inserted in parentheses at the end of the text for each entry. The overall classification/caveat of trials data pages is SECRET UK EYES B (inclusive of other caveats).***

Trial Codeword/ Nickname	Purpose of Trial	Report Reference
Trial ADDIS	Evaluation of Non-NATO missiles against IRCM flares fitted to Tornado F3. (Secret UK/US/Ger Eyes only).	CTTO/72/211/Tr Feb 92
Trial ACCUSED	Effect on EO sensors (FLIR and NVG) of distractions (Tracer, bombs, flares and fires) in the target area. (Confidential).	CTTO/72/204/Tr Mar 93
Trial ALBERTA	Acquisition and flight trials of SA-9 and determination of defensive tactics (Secret CAN/UK/US Eyes only)	CTTO/70/48/TR 28 Mar 85
Trial ALIGHT	Sky Shadow Operational Software Threat Specification.(Secret UK Eyes B)	EWOS FE21387 31 Jan 91
Trial ARROMANCHES	(Trial Instruction only) Evaluate new RHWR PFMs and tactical implications thereof. (Restricted).	CTTO/72/111/Tr Jan 89
Trial ASTRODOME	Determination of optimum techniques for operational employment of AIM-9L on Tornado GR1. (Confidential).	SAOEU/1550/59/Air May 88
Trial BEGONIA	Evaluation of GMR in anti-surface warfare role. (Confidential)	CTTO/72/181/Tr 25 Oct 93
Trial CARLO	IR Decoy Flares - Dispensation and Measurement of Performance against Ground Sensors. (Restricted)	A&AEE Report AR 13/91 Mar 91
Trial CAMEL	Update to Software SP7- X902 for Op GRANBY. Aircrew Briefing Guide (Restricted)	Letter COT/5618/1/TISMT 25 Jun 91

Trial COBNUT	Evaluation of Tornado "high level" and dive bombing with free-fall bombs. (Confidential)	CTTO/72/161/Tr Apr 92
Trial CONVENTUAL	Joint SAOEU/A&AEE Trial - Investigation of Feasibility of Lateral Toss (Restricted)	A&AEE Report NR 108/91
Trial COSHAM	Validation of designation and delivery techniques for LGBs from medium level. (Secret).	CTTO/72/157/Tr Jan 91
Trial COWL	Determination of performance improvements offered by de-chirped AIL-9L and validation of theoretical prediction. (Secret UK Eyes B)	CTTO/72/113/Tr Aug 90
Trial DAZE	Operational evaluation of Tornado weapon delivery modes and associated tactics (Secret)	TOEU/1550/3/Air Apr 84
Trial DWIGHT	(First Impression Report) Evaluation of effectiveness and performance of advanced UK IR flares as counter to Soviet and Western IR missile seekers. (Secret)	CTTO/72/136/Tr Jun 91
Trial ENSTATE	Determination of protection afforded by IR decoys released from BOZ 107 against SAM. (Secret)	CTTO/72/38/Tr Dec 84
Trial EPIGONE	OT & E of RHWR, and investigation of interaction between RHWR and Sky Shadow ECM pod. (Secret)	CTTO/72/51/Tr Nov 85
Trial EXCEED	The evaluation of the effects of chaff and directional J-band jamming on the Tornado TFR. (Secret)	CTTO/72/48/Tr Nov 86
Trial HOUSEKEEPER	The development of tactics for RAF aircraft to counter AA-8 (APHID) (Secret)	CTTO/72/42/Tr May 86
Trial KID	Evaluation of BAe modifications to reduce the RCS of Tornado and the benefit of decreasing burnthrough range of FCR against Sky Shadow ECM pod. (Secret UK Eyes B)	CTTO/72/29/Tr Jan 85
Trial KIX	Jaguar operations from reduced length runway (MOS) and subsequent AAR procedures. (Secret)	CTTO/72/16/Tr Aug 80
Trial LEINSTER	The evaluation of the effects of the SPN-40 DOG CART jammer on the Tornado GR1/1A GMR and TFR. (Secret)	CTTO/72/152/Tr Aug 91

Trial MACE	MACE is the generic name for a series of NATO sponsored trials. The main ones affecting Tornado are:	
	MACE III - Chaff against FCRs. (Secret)	Tracor Inc Aug 83
	MACE III - RCS data. (Confidential)	CTTO/32/22/10/EW Jun 82
	MACE IV, Pt1 - Co-ordinated chaff and jamming against FCR, and measurement of RCS. (Secret)	CTTO/72/85/Tr Mar 87
	MACE IV, Pt2 - Co-ordinated chaff and jamming against FCR, and measurement of RCS - Data. (Secret)	CTTO/72/85/Tr Jan 88
	MACE V (follow on) - ECM Co-ordinated chaff and jamming against FCR. (Secret)	DRA Farnborough Tech Memo MTC 32 Nov 92
	MACE V - Analysis of Terminator Radar. (Secret)	MPB Technology Quebec - Jun 92
	MACE VI - Improvements in ECM/Tactics (Trial in France) (Nato Secret)	AC/224/AG111 1 Feb 92
	MACE VI - Aircraft RCS measurements (Trial in France) (Nato Secret)	AC/224/AG111 4 jan 94
	MACE VII - Chemring First Impression Report (Secret)	P38/92/12 25 Feb 92
	MACE VII - DRA Farnborough First Impression Report (Secret UK Eyes A)	WP MTC 92 1 Sep 92
Trial MAYCOCK	Validation of MiniLoft delivery of FF bombs (Confidential)	CTTO/21/4/2/Air Feb 84
Trial MINATURE	Evaluation of formation procedures at High AUW. (Confidential)	TOEU/1550/32/Air Sep 85
Trial NONIYS	Operational evaluation of 2250 litre tanks. (Confidential)	SAOEU/1550/71/Air Jul 89
Trial OUTLINE	The determination of the deception ranges of Tornado GR1 avionic sub-systems by typical WP ESM receivers.	CTTO/72/77/Tr Jun 88
Trial PEACH	Initial Evaluation of NVGs (Secret)	TOEU/1550/49/Air Jul 89
Trial PEACH	Trial in Six Stages - Development of NVG Capability - Final Summary. (Confidential)	CTTO/72/142/Tr Feb 92

Trial PEACH	Stage 6 - Generation 3/ MOS Trial (Confidential)	CTTO/72/142/Tr Jan 92
Trial PHASIA	PHASIA is the generic name for a series of trials. The main ones of interest to Tornado operators are:	
	1. PHASIA 2 - Co-operative Modulated Jamming (Two Tornados). (Secret)	CTTO/72/46/Tr Apr 85
	2. PHASIA 3 - Evaluation of Sky Shadow and BOZ 107 pod in chaff mode. (Secret)	CTTO/72/46/Tr Jan 86
	3. PHASIA 3 - Analysis of Results (Secret)	ORB Memo 2/85 Apr 86
	4. PHASIA 3 - Software and Firmware Report . (Secret)	Marconi Report Dec 85
	5. PHASIA 3 - Post Trial Analysis (Secret)	Marconi Report Dec 85
	6. PHASIA 3 - Post Trial Analysis - Spurious Emissions. (Secret)	Marconi Report Apr 86
	7. PHASIA 4 - OT&E and DT&E of Tornado GR1 EW Suite - Sky Shadow update, BOZ 107, and Validation of Tactics evolved during PHASIA 3. (Secret)	CTTO/72/46/1/Tr Dec 86
	8. PHASIA 4 - Post Trial Analysis (Secret)	Marconi Report Aug 87
	9. PHASIA 5 - Initial Impression Report Evaluation of Proposed Tornado GR1 Tactics for Optimum Employment of EW Suite. (Secret UK Eyes B)	CTTO/72/46/2/Tr Jan 91
	10. PHASIA 5 - Final Report Evaluation of Proposed Tornado GR1 Tactics for Optimum Employment of EW Suite. (Secret UK Eyes B)	CTTO/72/46/2/Tr Nov 91
	11. PHASIA 5 - Results Data (Secret UK Eyes B)	CTTO/72/46/2/Tr Nov 91
	12. PHASIA 5 - Contractor's Report (Secret UK Eyes B)	Marconi Nov 90
	13. PHASIA 5 - Contractor's Report RHWR Performance (Secret UK Eyes B)	Marconi SLM 8681 Feb 92
Trial PULVERIZE	The validation of the measures described in the Tornado GR1 Tactics Manual to counter the effects of jamming on the Tornado GR 1 radars. (Secret)	CTTO/21/1/Air Jun 83

Trial REGENCY	The establishment of progressive TF letdown procedures. (Restricted)	TOEU/1550/9/Air Dec 84
Trial RHOPALIC	The evaluation of the performance of TFR against man-made obstacles. (Restricted)	A&AEE Report APF/195/04/26/2 Apr 88
Trial RHYTHMIC	The investigation of the feasibility of flying TF manually using the E-scope as a primary display for terrain avoidance. (Confidential)	TOEU/1550/17/Air Oct 86
Trial RIBSTON	Evaluation of capability of GMR to acquire and mark fixed and mobile targets. (Confidential)	TOEU/1550/31/Air Jun 85
Trial ROYDON	The investigation of the use of TFR by aircraft in tactical formations. (Restricted)	A&AEE Report PE/GR1/3 Mar 86
Trial RUBELLITE	The establishment of the optimum operational techniques for the transition between TF flight and loft manoeuvres. (Restricted)	TOEU/1550/8/Air Jul 84
Trial RUBIAN	The assessment of the cockpit workload of a crew using the GMR to monitor the TFR when flying in auto and manual TF over differing terrain at varying SCHs. (Restricted)	TOEU/1550/10/Air Feb 85
Trial RYE	(First Impression Report) - Operational and Technical Evaluation of Performance of SA-13 and SA-16 missiles against Military Aircraft and IRCM Self-protection Systems. (Secret UK Eyes B)	CTTO/72/188/Tr Jul 92
Trial RYE	Trials Data - Seeker Results (Secret UK Eyes B)	BAe Report BT 29011 1 Nov 92
Trial SEDGE 2	Test of MFBF fitted to 1,000lb Bomb and 2 HADES Weapons. (Confidential)	CTTO/72/133/Tr Sep 91
Trial SLEUTH Ph3	Evaluation of Main Computer Software - SP7-3 v4. (Restricted)	A&AEE, NR12/90 Mar 90
Trial SPARE	Stage 1 - Development of Counter Air Tactics against Representative Airfields (Confidential)	CTTO/21/4/1/Tr Jun 83
Trial TAPSTER	Joint A&AEE/TOEU Trial - Evaluation of Tornado as delivery vehicle for UK 1,000lb LGB. (Confidential)	A&AEE Report NR 52/85 Dec 85

Trial TRADAR	Joint A&AEE/TOEU Trial - Establishment of Accuracy of all Height Measurement Systems fitted to Tornado. (Confidential)	A&AEE Report NR 69/86 Jan 87
Trial TUMULT	Mini Loft Attacks (Stages 1, 3 & 4) (Confidential)	TOEU/1550/5/Air May 84
Trial TUNA	Effect of Auto-Throttle on Fuel Consumption (Restricted)	TOEU/1550/15/Tr Mar 87
Trial TWIBILL	Tornado GR1 Evasive Manoeuvre Study (Secret)	ORB Memo 3/88 - Nov 88
Trial TWO	Determination of most suitable radar reflector for use with GMR. (Secret UK Eyes A)	CTTO/72/150/Tr Jul 91
Trial TYNE	Development of Tornado Techniques for the Delivery of JP233. (Secret)	SAOEU/1550/25/Air Feb 86
Trial TYNE 2	Release of 2 production JP233 weapons, in short stick, against a representative target from a Tornado flying at operational heights and speeds. (Secret)	SAOEU/1550/25/Air Nov 86
Trial TYNE 3	Determination of effects of weapon aiming software on techniques for delivering JP233. (Secret)	SAOEU/1550/25/1/Air Feb 87
Trial TYNE 4	Release of modified production JP233 weapons, in short and long stick, against a representative target from a Tornado flying at operational heights and speeds. (Secret)	SAOEU/1550/25/Air Aug 89
Trial TYNE 5	Release of 20 modified SG357 SM and a surveillance HB876 JP233 weapon at RAE West Freugh. (Restricted)	CTTO/72/148/Tr May 91
Trial WRENTHAM	Joint A&AEE/ TOEU Trial - Overall Weapon System Accuracy in several stages	A&AEE Reports
	1. TF Elevation-Moding and Accuracy Assessment. (Confidential)	NR 9/86 Mar 86
	2. Loft Attacks- Determination of Vertical Corrective Term. (Confidential)	NR 13/86 May 86
	3. Loft Salvo Bombing - Moding and Accuracy Assessment. (Confidential)	NR 16/86 Nov 86
	4. Phase 2/3 Bombing: HUD Symbology Corrective Term. (Confidential)	NR 57/86 Oct 86
	5. Stick Bombing - Moding and Accuracy Assessment. (Confidential)	NR 3/87 Mar 87

	6. MTR Attacks - AGR Accuracy and Effects of Smoke. (Confidential)	NR 7/88 Apr 88
Trial YOCKLETON 4	Evaluation of RAF Tactics and Equipment against FULCRUM (at ACMI Decimomannu). (Secret UK Eyes B)	CTTO/72/151/1/Tr Nov 91

INTENTIONALLY BLANK

MISCELLANEOUS REPORTS

	Subject	**Reference**
1.	An Analysis of Runway Attack using JP233.	HQSTC ORB Memo 2/89
2.	Effectiveness of Chaff in Penetration of a Dense Threat Environment.	HQSTC ORB Memo 3/84 21 Sep 84
3.	Notes on JP233 Sub-munitions.	HQSTC ORB Report STC/60791/5/ORB - 15 Jan 91
4.	Analysis of Attack and Recce Operations during Operation GRANBY.	HQSTC ORB NFR 01/91
5.	Operation GRANBY: JP233 Analysis.	HQSTC ORB NFR 9/91
6.	Numbers of JP233 Munitions on Aircraft Operating Strips at Different Cutting Angles.	HQSTC ORB NFR 8/91
7.	SG 357 Performance Trials against Thickened WP runway Targets.	RARDE Div Wk Paper 11/89

INTENTIONALLY BLANK

Section 2

Terrain Following

Chapter 1 TF System Capabilities and Limitations

2 TF System Monitoring

SECTION 2 - TABLE OF CONTENTS

CHAPTER 1 - THE TF SYSTEM CAPABILITIES AND LIMITATIONS

Page Number
(within the Chapter)

TF SYSTEM CAPABILITIES 1

Effects of Jamming and Chaff........ 1
    Effect of Low Power Jamming........ 1
    Effect of High-Power Jamming........ 1
    Effect of High-Power Jammer on Sidelobe Suppression........ 1
    Effect of Jammer Bearing........ 4
    Effects of Sky Shadow Jamming........ 4
    Effect of Chaff........ 4

ECCM Features........ 4
    Frequency Agility........ 4
    PRF Jitter 6
    Pulse-to-Pulse Correlation........ 6
    Sidelobe Suppression........ 6
    Monopulse Elevation Beam........ 6
    Video Presentation........ 6
    Weather Modes........ 6
    Anti-Jamming Mode (Post-Mod 11133)........ 6
    Anti-Chaff Mode (Post-Mod 11133)........ 7

Countering Jamming 9
Countering Chaff........ 9

TF SYSTEM LIMITATIONS........ 10

Beacon Effect 10
TF/Climb Limitations 10
TF Bank Limitations........ 10
Radar Limitations........ 10
    Water........ 10
    Snow 10
    Tropical Vegetation........ 11
    Sand 11
    Man-Made Obstacles 11

CHAPTER 2 - TF SYSTEM MONITORING

INTRODUCTION 1

CREW CO-OPERATION........ 1
Effect of Terrain 1
TF Flight Conditions........ 1
    Auto TF........ 1
    Manual TF........ 1
    E-Scope TF........ 1
Anomalous Returns 2
Vital Areas of Crew Commentary........ 2
Radar Controls........ 2

TF TRAINING..3

MANUAL E-SCOPE TF PROCEDURES..3
Cockpit Scan Pattern...3
Crew Commentary..3
Pilot Operating Procedures...3

CHAPTER 1 - THE TF SYSTEM CAPABILITIES AND LIMITATIONS

INTRODUCTION

1.(U) The most significant advance in capability provided by Tornado is its ability to operate effectively on overland missions in non-visual conditions. This has been made possible primarily by the incorporation of a TF system. Before deciding on the best methods for tactical employment of this system it is important that Tornado aircrew understand its capabilities and limitations. The aim of this chapter is to discuss those capabilities and limitations in areas that will directly affect the tactics recommended in later Sections of this Manual.

TF SYSTEM CAPABILITIES

2.(U) A description of the TF system and its capabilities is contained in the Aircrew Manual Book 1, Part 1, Chapter 10. The E-Scope referred to throughout this manual is the enhanced E-Scope Display post-Mod 00411.

3.(S) **Effects of Jamming and Chaff.** The aim of TF jamming is to force the aircraft to climb into an AAA or SAM engagement zone. This situation can be avoided if the E-Scope is carefully monitored because the display will enable the crew to observe the effects of the jamming and to decide on the action to nullify those effects. It is likely that ground based jammers will have the capability to jam the TFR in spite of its ECCM features. The effects of the generic J-band jammers on the TFR were evaluated during Trials PULVERIZE and EXCEED; the latter trial also evaluated the effects of chaff. More recently a quick-look assessment of the effects of the DOG CART jammer was carried out during Trial LEINSTER. Typical effects of jamming are as follows:

a. **Effect of Low Power Jamming.** Figure 2-1-1 shows low power jamming breaking through on the E-Scope display. The jamming penetrates neither the Zero Command Line (ZCL) nor the Clearance Range Ahead Monitor (CRAM) so no climb command is generated.

b. **Effect of High-Power Jamming.** If the power of the jamming is increased, the E-Scope display shown at Figure 2-1-1 will change to that shown in Figure 2-1-2. The jamming penetrates the ZCL and the CRAM, and a pull up command will be generated.

c. **Effect of High-Power Jammer on Sidelobe Suppression.** High-power jamming may be powerful enough to cause jamming signals to enter the TFR antenna sidelobes, however the sidelobe suppression will normally prevent such signals appearing closer than 3 nm. At short ranges a jamming signal entering the TFR antenna sidelobes may have sufficient power to cause the sidelobe suppression system to switch-out. In this case, the sidelobe jamming illustrated in Figure 2-1-2 will appear within 3 nm (see Figures 2-1-3 and 2-1-4), penetrating both the ZCL and CRAM, and causing a pull-up command. It is important to note that although the main beam and sidelobes are likely to be affected by jamming simultaneously, the effects shown in Figures 2-1-3 and 2-1-4 can be caused by sidelobe penetration alone.

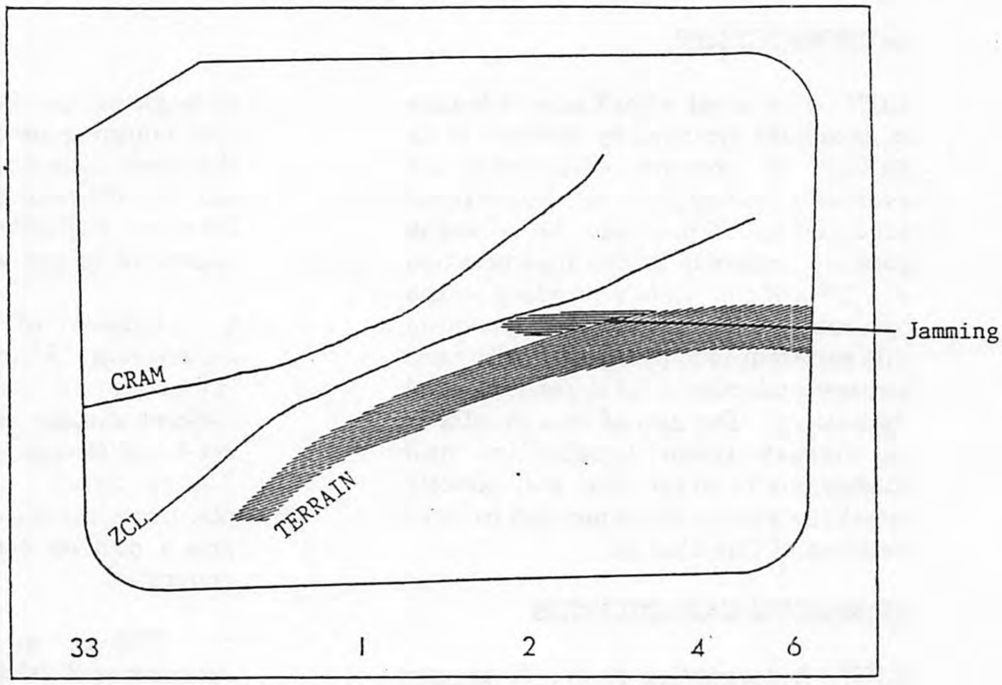


Figure 2-1-1(S) - Low-Power Jammer in Main Beam

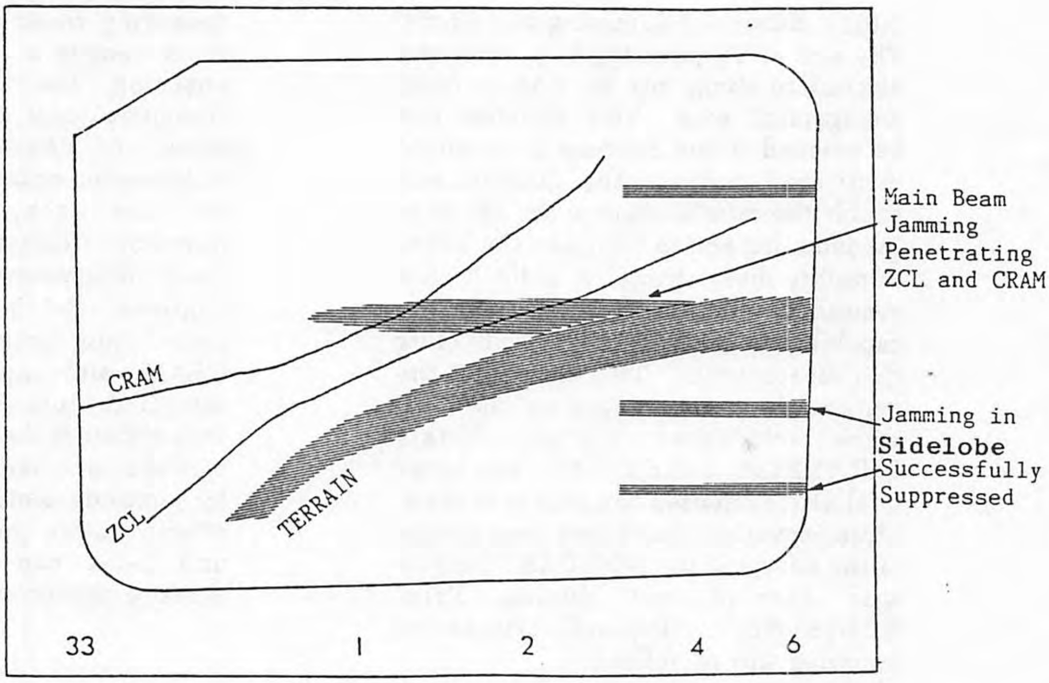

Main Beam Jamming Penetrating ZCL and CRAM
Jamming in Sidelobe Successfully Suppressed
CRAM
ZCL
TERRAIN
33
1
2
4
6

Figure 2-1-2(S) - High-Power Jammer in Main Beam

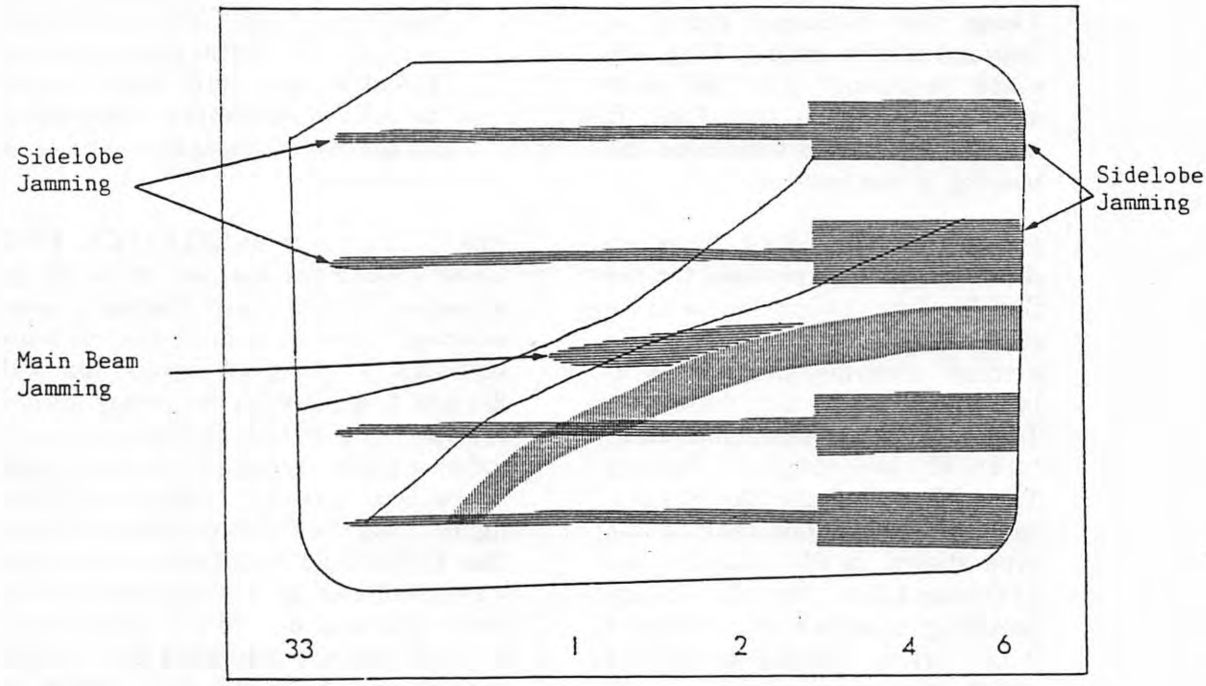


Figure 2-1-3(S) - Powerful Jammer in the Main Beam Causing Sidelobe Suppression Breakdown

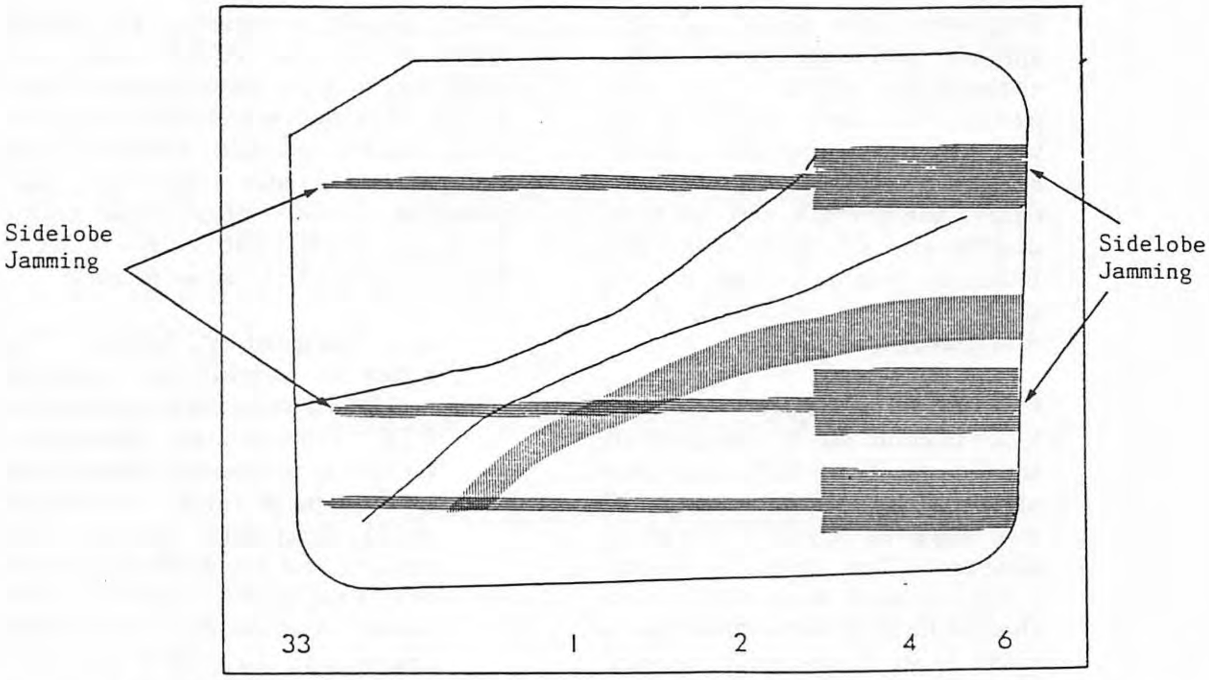


Figure 2-1-4(S) - Powerful Jammer in Sidelobes Causing Sidelobe Suppression Breakdown

d. **Effect of Jammer Bearing.** A turn away from the jammer of as little as 10° could reduce its effectiveness. Assessing the bearing of a jamming signal using the E-Scope alone is impractical (Pre-mod 11133), but since jamming may be seen simultaneously on the GMR, it AND RHWR may be possible to determine the bearing of the jammer.

e. **Effects of Sky Shadow Jamming.** It is possible for the Sky Shadow transmissions to be received both by the TFR of the aircraft carrying the pod (self-jamming) and by following Tornados of the same formation (mutual jamming). During Trial PHASIA 3 the Sky Shadow caused sidelobe jamming of the type shown in Figure 2-1-1 but occasionally main beam jamming occurred as in Figure 2-1-2. It is difficult to predict when this self-jamming will occur, as it has been experienced when Sky Shadow has been countering threats out of the TFR frequency such as the S-60 FLAPWHEEL radar in its frequency agile mode. If only sidelobe jamming occurs 'climb' commands should not be generated, but main beam jamming will cause false 'climb or pull up' commands. In both cases, the terrain can be seen plainly and TF flight using the E-Scope display alone should allow any false commands to be disregarded.

f. **Effect of Chaff.** Almost all types of chaff will be displayed on the E-Scope if they fall in the beam of the TFR. Newly sown chaff will show as a small bright-up similar to that shown in Figure 2-1-5 but older more widespread chaff is likely to show more like a cloud as in Figure 2-1-6. Again, chaff is likely to generate a 'climb or pull up' command if the ZCL/CRAM are penetrated but, if recognized, chaff can be flown through manually using the E-Scope; however, man-made obstacles could not be distinguished from the effects of BOZ 107 chaff during Trial EXCEED. The TFR of Tornado aircraft in formation may be affected by chaff from other formation members, depending on the lateral separation and trail distance.

Note: During Trial LEINSTER, DOG CART caused the the aircraft to fly-up in auto-TF when fixed frequency was selected; however, ground returns were sufficiently clear to allow manual E-scope flying. With frequency agility selected, the effects of jamming were substantially reduced; the aircraft contoured correctly, albeit slightly higher than the SCH and did not fly up. The DOG CART was operated in what was considered by Tech Int (Air) as its most potent mode - MIP I plus noise - through the trial. Although the Tornado used during the trial had an EV3 nose radar, the new ECCM features introduced in this standard of radar (see paras 4h and 4j below) were not used.

4.(S) **ECCM Features.** The ECCM features of the TFR, which are enhanced with the embodiment of Mod 11133 (introduction of EV3 standard nose radar), should permit it to recognize its own signal in the presence of other alien pulse trains such as GUNDISH. The ECCM features in the TFR are as follows:

a. **Frequency Agility.** The radar is capable of frequency agility; however, the variation in TFR transmitter frequency follows a sinusoidal pattern and is thus predictable. A jammer could, therefore, exploit this pattern and could effectively jam the TFR using relatively low power. As a result it is vital that crews use the TFR in fixed frequency whenever possible, in both peace and war, to protect this important ECCM feature.

AL2 (MS)

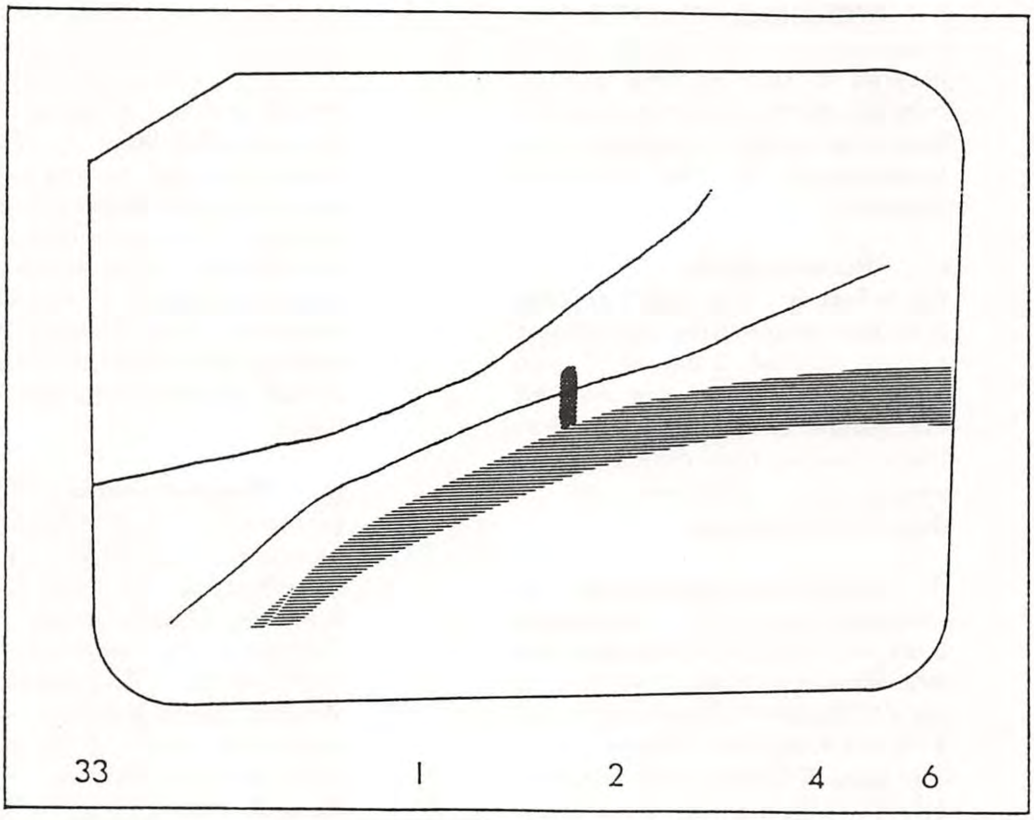


Figure 2-1-5(S) - Recently Sown Chaff

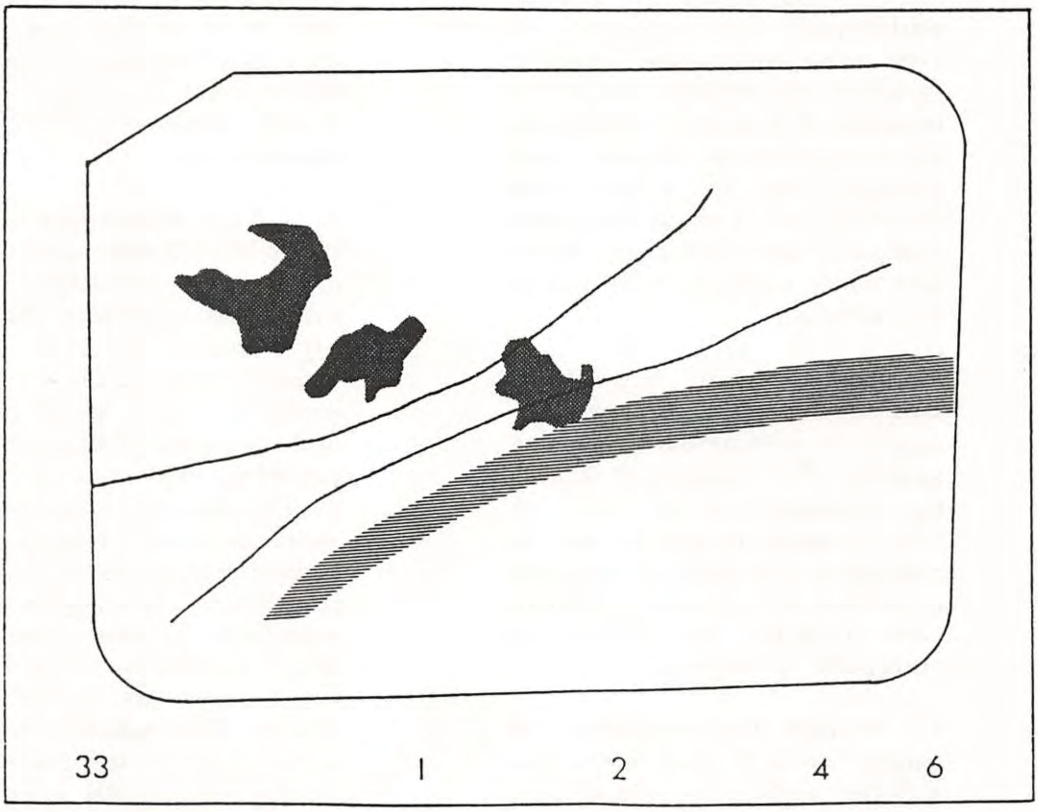


Figure 2-1-6(S) - Well Developed Chaff

b. **PRF Jitter**. The PRF of the transmitter is continuously jittered so that returns coming from an enemy deception jammer should be readily recognised and suppressed by the receiver processor.

c. **Pulse-to-Pulse Correlation**. The radar returns from four consecutive transmitter pulses beyond 3 nm, and two pulses within 3 nm, are checked for range correlation so that transmissions from deception and swept noise jammers can be detected and rejected.

d. **Sidelobe Suppression**. An electronic "guard horn", processing channel, more sensitive than the sidelobes of the main receiver, is used to suppress returns from the TFR sidelobes (See Figure 2-1-7). The main TFR processor will only accept signals of a greater strength than those from the guard channel receiver, thus eliminating unwanted sidelobe returns. This mechanism has the additional advantage of overcoming low powered jamming signals in the sidelobes but, in the presence of high-power jamming, the guard channel will switch out allowing both the ground and jamming to be seen by the radar processor; the effect of the latter may cause a pull-up command to be generated.

e. **Monopulse Elevation Beam**. The radar is a two lobe amplitude comparison monopulse system. This effectively reduces the beamwidth of the radar, so that a jamming signal can be rejected if the radar is painting other than the jammer's position, thus making the TFR less susceptible to jamming.

f. **Video Presentation**. At ranges greater than 3 nm the E-Scope provides the pilot with an unprocessed video display. Therefore the display is more sensitive to jamming than the data being fed to the TF computer. Initially pre-processing will smooth out the jamming effect in the computer, but if no corrective action is taken strong jamming may eventually break through and produce fly-up commands. Thus the E-Scope video indications of jamming beyond 3 nm provide a warning that jamming may subsequently affect the TF system unless positive crew actions are taken.

g. **Weather Modes**. The TFR performance is degraded by the presence of rain which appears as interference on the E-Scope. Weather Modes A and B are designed to minimise this degradation. The selection of Weather Mode A reduces receiver sensitivity and can be used for flight in heavy drizzle. Weather Mode B is not cleared for flight. If used, the receiver works at normal sensitivity, but range and upper scan limits are imposed on the computation data in the processor. Both of these facilities may be used in an attempt to reduce the effect of any jamming (Post-Mod 11133 Weather Mode B is redundant).

h. **Anti-Jamming Mode (Post-Mod 11133)** The selection of the anti-jamming (ANTI-J) introduces synthetic wall (SW) algorithms in the radar computer/processor which are designed to reject "ghost" obstacles and allow auto-TF flight through a jamming environment without closed/open loop pull-ups. The wall is drawn as a dashed line at a defined gradient to the discernible terrain as in Fig 2-1-8; in dynamic conditions, ie over moderate or severe terrain, the dashed line on the E-scope can be difficult to discern. Penetration of the SW by jamming causes the aircraft to fly up but the aircraft maintains a profile closer to the ground than with the pre-Mod 11133 standard

AL2 (MS)

radar. The CRAM line is displayed through the elevation band of the jamming source, and the CRAM function is inhibited over this sector (jamming radar returns which penetrate the dashed section of the CRAM line do not cause the monitor to trip).

i. **Anti-Chaff Mode (Post-Mod 11133)** Upon selecting anti-chaff (ANTI-C) mode the SW algorithms immediately come into effect whether there is any jamming or chaff present. The algorithms process all radar returns. If the algorithms determines that a return is from terrain then the synthetic wall range is made coincident with the range of the return; if the return is deemed not to emanate from terrain (jamming/ chaff/ weather), then the wall is set at a range based on a defined terrain gradient from the last 'valid' terrain return as in Figure ~~2-1-8~~. 2.1.9 The SW is displayed on the E-scope as a dashed line which, in the absence of jamming or chaff, appears superimposed on or just above the terrain returns. The CRAM is displayed as a dashed line for pilot monitoring purposes only. Incursion of the CRAM line by terrain or ECM at any time while the mode is selected, does not result in a pull-up.

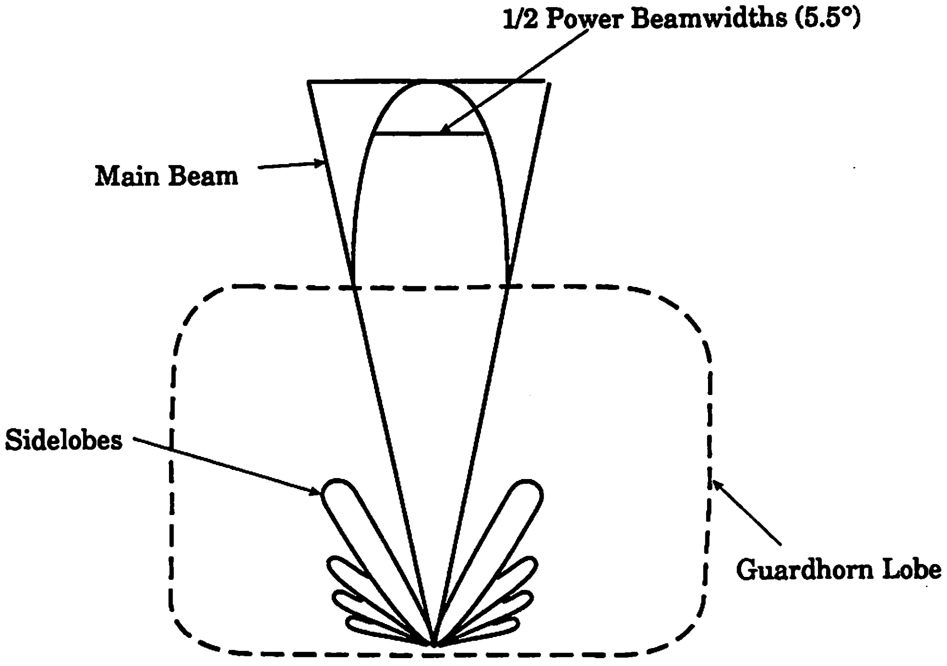
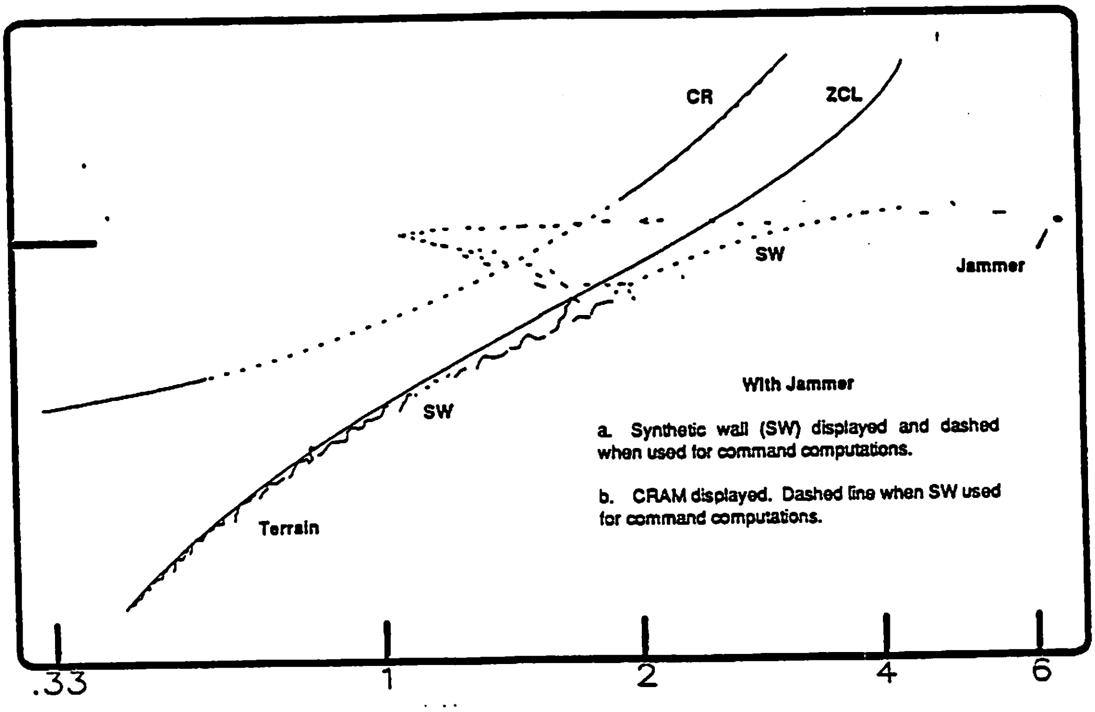


Figure 2-1-7(R) - Polar Diagram of TFR Antenna

4L2 (MS)

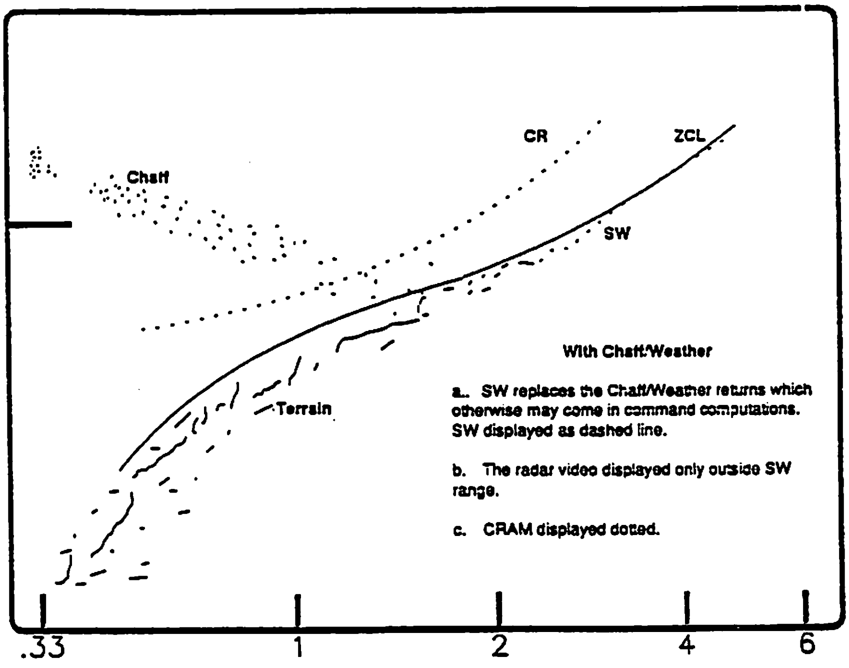


With Jammer

a. Synthetic wall (SW) displayed and dashed when used for command computations.

b. CRAM displayed. Dashed line when SW used for command computations.

Figure ~~2-1-7~~(R) - Anti-Jamming Mode(Post-Mod 11133)
2-1-8



With Chaff/Weather

a. SW replaces the Chaff/Weather returns which otherwise may come in command computations. SW displayed as dashed line.

b. The radar video displayed only outside SW range.

c. CRAM displayed dotted.

Figure ~~2-1-8~~(R) - Anti-Chaff Mode (Post-Mod 11133)
2-1-9

AL2 (MS)

5.(S) **Countering Jamming**. Trials PULVERIZE and EXCEED concluded that the following selections should be made to avoid and counter TF jamming.

a. When operating in an area where TFR jamming may be expected:

(1) Select lowest possible SCH - terrain mask if practical.

(2) Select Hard Ride.

(3) Select Frequency Agile mode

b. When main beam jamming appears within 3 nm range on the E-Scope or sidelobe suppression ceases to function:

(1) Select Weather Mode A.

(2) If practical, change track by 10°.

(3) If jamming disappears continue with new track.

(4) If jamming re-appears as sidelobe jamming and penetrates the ski-toe within 3 nm on E-Scope, consider further 10° track change in same direction as sub para (3) above.

(5) If pull-up occurs ICO. Pre-Mod 11133, if sidelobe jamming penetrates the ski-toe despite the further track change, or change of track is not desireable as (3) and (4) above and main beam jamming leaves the terrain line, deselect auto pilot or ICO.

(6) Fly by reference to E-Scope using ground returns and the ZCL in accordance with Chapter 2 paras 9 to 11.

(7) Re-select auto-TF as soon as E-scope is clear.

Note: Trial EXCEED questioned the validity of turning to avoid the jammer. However, Trial LEINSTER clearly demonstrated that there was a reduction in jamming when a slight turn away was made from the DOG CART. In addition, Trial LEINSTER recommended that transmitting on the GMR should be considered in the event of main beam, jamming as this action caused a step reduction in the level of TFR jamming during the trial.

6.(S) **Countering Chaff.** Trial EXCEED concluded the following selections should be made to avoid and counter chaff:

a. When operating in areas where aircraft ahead are likely to be dispensing chaff:

(1) Select Hard Ride.

(2) Select Weather Mode A.

(3) Use GMR to search for chaff. If detected, initiate turn to avoid chaff before it effects E-scope.

(**Note**: Selection of Fixed Frequency or Frequency Agile is immaterial against chaff.)

b. If chaff is not detected, as para 6a(3) above or turn not practical, then:

(1) Monitor chaff detected on GMR or E-scope and deselect auto pilot or ICO when effects of chaff appear on E-scope at ranges of less than 3 nm (pre-Mod 11133) or ICO if pull-up occurs.

(2) Fly by reference to E-scope using ground returns and the ZCL in accordance with Chapter 2 paras 9 to 11; maintain track.

(3) Re-select auto-TF when E-scope is clear below 3 nm.

TF SYSTEM LIMITATIONS

7.(S) **Beacon Effect.** The TFR main beam acts as a long-range beacon whenever it is switched on. Whilst this beam only covers a limited arc on either side of track, it was noted during Trial OUTLINE that the radar's side lobes are very detectable over a very much wider arc up to ranges in excess of 15 nm. Even allowing for terrain screening, it is likely that these sidelobes would be detected at useful ranges and could jeopardise the safety of the aircraft. Since there are no other measures available other than to attempt to terrain screen, it is advisable that use of the TFR is kept to a minimum commensurate with successful completion of the operational mission.

8.(R) **TF/Climb Limitations.** The TF climb/dive limitations are as follows:

a. Maximum aircraft climb of 30°.

b. Maximum dive of 10°.

9.(C) **TF Bank Limitations.** The maximum bank angle during Auto-TF is 45°. However, the bank angle commanded is subject to a maximum turn rate limitation of 1.9°/sec which will result in commanded bank angles of less than 45° with variations of TAS and vertical acceleration within the maximum limits. The TF system is roll stabilized up to 60° of bank and in Manual mode the aircraft could be flown to this limit, but the manoeuvre monitor is activated at bank angles that exceed maximum turn rate. The total 'g' required for the aircraft to meet both a vertical TF command and a turn may exceed the authority of the Autopilot and Flight Director System (AFDS), in which case the AFDS will give priority to the pitch command and decrease bank accordingly to remain within the limit. Thus when crossing a ridge in a turn, the aircraft may roll out of the turn as it climbs the ridge, and resume the turn and descend as it crests the ridge when the TF climb command is removed. Both of these will have the effect of increasing the radius of turn; therefore, where possible, TF routes should be planned to avoid turns over terrain which would require a simultaneous increase in pitch.

10.(C) **Radar Limitations.** The ability of the TFR to 'see' obstacles and terrain depends on a number of factors which include the grazing angle and the reflectivity of the surface being illuminated.

a. **Water.** The TF radar cannot see calm water. However the radar altimeter input to the TF computer (altimeter override command) takes over and enables continued safe operation of the TF system.

b. **Snow.** During trial flights over Scotland, where the snow is generally wet, the TFR has performed correctly. However, dry, powdery snow normally presents a poor radar reflecting surface. Crews should expect reduced performance over ground covered with dry snow, particularly when the snow is covering the top of gently sloping ridges. In addition, when approaching facing slopes where pockets of deep snow are formed at the base of inclines, the E-scope is likely to show returns similiar to weather (rain) below the normal terrain and, occasionally, extending above the terrain into the CRAM line causing unnecessary pull-ups. Over frozen lakes which have a covering of snow only limited E-scope returns can be expected and it is likely that the TF system will be controlled by the rad alt. For example, during SAOEU sorties in Canada when flying with a SCH of 200ft the E-scope showed good returns out to 1 nm after which the returns were either very broken or not visible at all.

c. **Tropical Vegetation.** During Exercise IADS 90-2, 27 Sqn flew a number of sorties over 3 types of tropical vegetation: primary jungle, secondary jungle, and plantations. A subjective assessment indicated that the TFR will treat all 3 types in a similiar manner and will maintain the SCH with reference to the main canopy of the vegetation. However, the TFR was only used over areas where the vegetation provided a close canopy. Furthermore, there was insufficient data to determine whether the TFR saw individual tall trees.

d. **Sand.** Smooth rolling sand and dry lake beds may also result in poor reflectivity, and certain formations of sand dune may not be detected by the TFR at all !

e. **Man-Made Obstacles.** The Tornado TFR cannot see power cables, but can see the pylons that support them. Provided that at least one pylon remains within the scan of the TFR, flight across power lines should not present a hazard. Trial RHOPALIC evaluated the effect of man-made obstacles on the TFR and concluded that while the TFR reacted correctly to steel masts, it could not be relied on to detect chimneys or objects of poor reflectivity such as cables, hang-gliders and small helicopters.

INTENTIONALLY BLANK

CHAPTER 2 - TF SYSTEM MONITORING

INTRODUCTION

1.(C) The primary aid to monitoring the TF system is the E-Scope. In addition, a number of automatic monitors are incorporated in the system, eg Manoeuvre Monitor (MM), CRAM, Low Height Warning and System Built-In Test Equipment (BITE). These monitors, when activated, will alert the crew with audio and visual warnings, Central Warning Panel (CWP) captions, and indications on the Flight Director (FD) system in the HUD and on the ADI. Certain monitors will activate an automatic pull-up when auto-TF is engaged. The overall task of monitoring TF flight can be helped by the use of the GMR and other navigation systems.

CREW CO-OPERATION

2.(R) Good crew co-operation will lead to an effective reduction in the TF workload, allowing more time to be devoted to countering enemy threat systems. The basis of crew co-operation is the independent and complementary monitoring of the aircraft systems, with commentary where required. The commentary should be kept to a minimum and will vary according to the type of terrain being over-flown and the TF flight conditions. The presence of jamming and the stage of attack will also have a bearing on the type of monitoring and commentary.

3.(C) **Effect of Terrain.** Generally, the flatter the terrain, the less commentary is required and vice versa. Over flat terrain the navigator should leave the GMR in stand-by and use the moving map display to warn the pilot of approaching high ground, pylons or town that could cause a climb command. The pilot should only comment when a cut-off is observed, he should then inform the navigator of its distance from the aircraft. The navigator should then use the GMR to confirm the presence of the cut-off before monitoring the flight path of the aircraft. Over hilly terrain the navigator should use the GMR continuously to give advance warning of high ground so that, where possible, it can be avoided using the heading acquire mode. In this type of TF flight, the pilot warns of an approaching cut-off, and the navigator confirms that the GMR is displaying a similar picture. If the navigator observes a cut-off within 3 nm that has not been commented on, he should inform the pilot. There should then be no need for either crew member to give further commentary until the ground returns "fill-in" beyond the cut-off or the aircraft does not climb correctly at the leading edge of the cut-off.

4.(C) **TF Flight Conditions.** The level of crew commentary required will vary depending upon the type of TF flight selected. It is possible to fly TF in three modes, namely:

a. **Auto TF.** In Auto TF mode the autopilot is used in conjunction with the TF system to maintain a SCH above the terrain.

b. **Manual TF.** In Manual TF mode the TF system is used to generate FD commands to be followed by the pilot and thus maintain a SCH.

c. **E-Scope TF.** In E-Scope TF mode terrain clearance is maintained with reference to the E-Scope alone.

Only Auto TF and Manual TF modes have been cleared for flight and when they are used the commentary can be kept to a minimum - as suggested above. Operationally, however, it may be necessary to utilise E-Scope TF to overcome jamming and chaff, or prevent nuisance pull-ups either in a high threat area or at a critical stage of an attack. Trial RHYTHMIC concluded that flying manual TF using the E-scope as the primary display for terrain avoidance is feasible but that pilot proficiency follows a very steep learning curve due to the difficulty and high workload. Therefore, it is essential to train using manual E-scope techniques in peacetime. Until Release to Service clearance is obtained training should be carried out in the simulator. Recommended manual E-scope TF procedures are given at the end of this Chapter.

5.(S) **Anomalous Returns.** A known occurrence in TF flight is the 'nuisance' pull-up caused by an anomalous return or "Beta Spike". The effect of these signals is to give a sharp climb command which could put the aircraft into the engagement zone of an enemy air defence system or cause a missed attack. These anomalous returns occur most often when the aircraft is approaching isolated buildings or smooth water/land interfaces. Modifications to the TF system such as using Radar Absorbent Material (RAM) in the radome and a RAM coating on the pitot tube may reduce or prevent these signals. Until suitable modifications have been incorporated and proven, however, nuisance pull-ups will occur. As stated in para 4 they may be overcome by using E-Scope TF, and over known flat ground (eg attack run) consideration could be given to using Radar Height Hold (RHH). NB. RHH OVERLAND NOT R TO S

6.(R) **Vital Areas of Crew Commentary.** Regardless of terrain or TF mode being used, a number of events in both cockpits should be included in the commentary to ensure that both crew members are forewarned of any changes in flight conditions.

a. The pilot must inform the navigator of any alterations to the following selections or indications:

(1) Engagement or disengagement of Autopilot.

(2) Selection of TF or RHH.

(3) Alteration in SCH.

(4 Indication of 'T' in the HUD.

(5) Selection of Hdg or Track acquire.

b. The navigator must inform the pilot before making the following selections:

(1) Selecting F/A on the TV Tab.

(2) Pressing the insert on the NHC when in F/A.

(3) Alteration in planned route.

(4) Changes to the Nav Mode.

7.(C) **Radar Controls.** Squadron crews who have been declared operational in the strike or attack role will have flown sufficient TF flights for them to have decided upon the optimum GMR settings to monitor TF flight. Basic settings and procedures which may be refined are as follows:

a. Over flat terrain the GMR may be left at INT and the 1:500,000, 1:250,000 or 10 nm (if available) map used to warn of approaching high ground or obstacles.

b. In hilly terrain the GMR should be used to monitor cut-offs.

c. The GMR scan angle should be either 15° or 30°.

d. The tilt angle should be "-0" and set on auto-tilt.

AL2 (MS)

e. 5 nm range rings should be selected.

f. Frequency agility should be used when ECM is encountered.

TF TRAINING

8.(C) The key to successful TF operations is TF training at operational heights and speeds. The TF system gives an artificially "softer" ride, regardless of the ride setting, for any selected SCH above 500 ft. This fact combined with the different radar picture above this height and the reduced psychological stress factor can make peacetime TF training unrepresentative of operational TF flight at 200 ft SCH. There is no easy solution to this problem except to make full use of the simulator, and to fly as many sorties as possible - in both VMC/IMC and day/night - at the lowest cleared SCHs. It must be emphasised however that the crew workload during day/VMC TF flights is not representative and is not therefore a substitute for 'real' TF flight in night/IMC. Thus it is important for aircrew to follow a dedicated comprehensive training programme over all types of terrain if they are to exploit the TF system to maximum advantage.

MANUAL E-SCOPE TF PROCEDURES

9.(R) Trial RYTHMIC concluded that flying manual TF using the E-scope as the primary display for terrain avoidance was feasible. However, the report also concluded that it was essential to train in peacetime using manual E-scope techniques, albeit in the simulator until Release to Service clearance was available. The recommended procedures are given in the following paragraphs.

10.(R) **Cockpit Scan Pattern.** The suggested cockpit scan pattern is centred on the E-scope for 60% of the time, returning to the E-scope after a glance at another display. Scan away from the E-scope should be to the HUD for 30% and other displays for 10% of the time. The other displays in the scan should be RPMD, for orientation and warning of terrain and obstacles, AFDS selections, fuel and engine indications. The head down AI should be brought into the scan during turns to assist in the monitoring of bank angles.

11.(R) **Crew Commentary**. During manual E-scope TF the pilot should call cut offs on the E-scope as in auto-TF and the navigator should confirm them on the GMR. However, additional commentary is required from the navigator to:

a. Talk the pilot around large man-made obstacles.

b. Call the roll-in and roll-out of turns.

12.(R) **Pilot Operating Procedures.** When TF flying pilots should:

a. Deselect auto pilot or ICO in accordance with Chapter 1, paras 5b(5) and 6b(1) and revert to manual E-scope flying using the scan pattern detailed in para 10 of this Chapter.

b. Select FD Track and auto-throttle on the AFDS during manual E-scope TF to assist in track holding and speed control.

INTENTIONALLY BLANK

Section 3

Threat

Chapter 1 Air Threat

2 Ground Threat

SECTION 3 - TABLE OF CONTENTS

CHAPTER 1 - THE AIR THREAT (CIS)

Page Number
(within the Chapter)

AD FIGHTERS 1

DEFENSIVE TACTICS 1
  Airfield Alert 1
  Airborne Alert 1
  CAP 1

CHAPTER 2 - THE GROUND THREAT (CIS)

THREAT SYSTEMS 1

RADAR JAMMERS 1

PASSIVE DECEPTION 1

INTENTIONALLY BLANK

CHAPTER 1 - THE AIR THREAT (CIS)

AD FIGHTERS

1.(S) All the fighters which are likely to oppose NATO's tactical aircraft will be gun and AAM armed. Although the introduction of FOXBAT E provided an improvement in the then WP's low level capability, the arrival of FULCRUM and FLANKER gave them their first true look-down, shoot-down capability. In addition to these 3 aircraft types, FISHBED and FLOGGER fighter variants are available for use in the AD role. Furthermore, there are smaller numbers of FITTER, FISHBED and FLOGGER variants whose primary role is ground attack but which have an AD capability.

DEFENSIVE TACTICS

2.(S) CIS defensive counter air tactics will most probably consist of standard GCI intercepts controlled from either ground or airborne alert stations. Historically, GCI intercepts comprise by far the largest category of air-to-air training in the old Soviet Union. GCI intercepts are conducted under strict supervision by the flight leader and the ground based controller in accordance with established procedures and rules of engagement. In the past, generally only one event was planned per sortie, probably due both to aircraft fuel limitations and to conservative training philosophy. Most intercept sorties from take-off to engagement are executed strictly under GCI instructions for initiation of climbs/descents, heading changes, speed and 'g' loading, selection of reheat, AI radar activation and clearances to fire. On those occasions when intercept training culminates in manoeuvring air combat (MACT), the ground controller relinquishes control to the pilot (or flight lead) and assumes a safety monitoring role. Once MACT is complete the ground controller resumes command to direct recovery to base.

3.(S) The fighters adopt several different defensive alert postures; these are outlined below:

a. **Airfield Alert.** Quick reaction defensive fighters are maintained at their counter air and interceptor bases. In peacetime there are normally 2 aircraft at each fighter/interceptor regiment on an airfield alert at all times. The CIS probably has a 5 min scramble requirement when reacting to intruders. In wartime, this requirement would probably be shortened.

b. **Airborne Alert.** During an alert the fighter is positioned in orbit at a designated point where it waits to be committed against a target. The air alert zone may be directly over the airfield or in a forward position.

c. **CAP.** The Soviets distinguish between fighters on an air alert and CAP even though the missions are very similar. Generally, CAP fighters range over a wide geographic area and react to threats either through GCI direction or by using on-board sensors; aircraft placed on airborne alert are always directed to a threat by GCI. The CAP could be flown as a simple oval racetrack - usually as a pair, but could comprise either a single aircraft or a 4-ship - or as an opposing racetrack with the element initially flying perpendicular to the axis of the expected attack. In addition, non-standard patterns could be flown for special situations and include spiral, figure of eight and triangular orbits.

4.(S) Historically, interceptors have conducted rear hemisphere intercepts as the primary method of engaging a target. With the arrival of the FLOGGER and FOXBAT and their limited all-aspect weapons capability a number of changes occurred in Soviet intercept tactics. There has been a progression from lock-up rear hemisphere intercepts against a non-manoeuvring target to the more dynamic environment including attacks against manoeuvring targets from all aspects. With the introduction of FULCRUM and FLANKER, front hemisphere attacks have now become common.

5.(S) FULCRUM intercept training is normally flown as a singleton although aircraft do operate in pairs for practising MACT; the primary form of intercept is a forward hemisphere intercept, probably with full GCI control, with a conversion to a rear hemisphere attack. (Of note are indications that the SLOT BACK radar currently may have problems retaining lock in the rear hemisphere). The bulk of the intercepts are medium level lock-up intercepts against a non-manoeuvring target. Low level intercepts are normally look-down and very occasionally the low level targets evade.

6.(S) A feature of many intercepts, most commonly rear hemisphere attacks, is the employment of EMCON procedures to AI radar emissions. The radar does not transmit until the interceptor has been positioned by the GCI control to within lock-on range and occasionally the aircraft's radar is not used until within missile launch range. For example, when FULCRUM has participated in AD exercises it has always held in an orbit with the pilots rarely, if ever, operating their radars; the radars are only switched on after the aircraft leaves the orbit.

CHAPTER 2 - THE GROUND THREAT (CIS)

THREAT SYSTEMS

1.(S) The two most important factors which determine whether a SAM can engage a target successfully are the system's capability and the aircraft's exposure time. Both system capability and aircraft exposure time are reduced in direct relationship to the speed and height at which the aircraft are flown. The missile capability is related to the missile miss distance, fuzing capability and warhead characteristics. Minimum effective altitude of a SAM system is that altitude at which the single shot kill probability has reduced to 20% for a radially-approaching standard target which has a radar cross-section (RCS) of 10 m^2. Of note, aircraft of the Tornado, Jaguar and Harrier type typically have a RCS of 10 m^2 on, or within 10° of the nose, which increases to many hundred m^2 on the beam for a fully armed aircraft! The minimum reaction time is defined as the time required to acquire a target with a fire control radar, complete the launch preparations and launch a missile plus the time taken for the missile to fly to the minimum engagement zone. The CIS use AAA to complement their SAM defences. The main threat at present is posed by 23 mm (ZSU 23-4) and to a lesser extent 57 mm guns; however, in the future, 30 mm AAA (2S6) is likely to replace 23 mm as the main threat. A large number of AAA systems are likely to be deployed tactically and the probability of random engagement by these systems is high, particularly in the forward areas. The threat posed by individual small arms to a high speed, low level target also exists, especially if concentrations of troops or armour are overflown. It should be noted that the general purpose machine guns carried by most modern ex-Soviet tanks would probably be used on the move to provide barrage fire against enemy low flying aircraft.

RADAR JAMMERS

2.(S) The CIS possess the capability to jam Tornado radars; in particular, Tornado operations are most vulnerable to TFR jamming. The primary ground based jamming threat to the Tornado TFR is posed by DOG CART which is a J Band repeater jammer which was initially deployed in the mid 1970s. It is assessed as being capable of auto-tracking in azimuth and, to some extent, tracking the PRF of targets. It is able to produce false targets both ahead of and behind its ground position and, in addition, it can probably transmit a continuous noise jamming signal. To be effective the jamming needs to be powerful which implies a jammer with high antenna gain and thus narrow beam width and therefore DOG CART is not ideal for this purpose. Limited data on DOG CART performance against Tornado GMR and TFR was obtained during Trial LEINSTER. Recent intelligence about PAINT BOX indicates that coverage of this system is probably limited to I Band/ low J Band and therefore it is not a threat to Tornado. In the future, HIP-J might pose a limited jamming threat to Tornado; whilst airborne jammers offer many advantages over their ground based counterparts, they suffer from lack of power. Jammers would probably be used to support the major thrusts and also defend high value second echelon or rear area targets. Trial EXCEED evaluated the effects of chaff and jamming on the Tornado TFR and devised countermeasures.

PASSIVE DECEPTION

3.(S) CIS forces are likely to employ passive radar deception techniques by dispersing radar reflectors around prime targets to distort the natural radar returns. For example, a line of reflectors deployed across a river next to a bridge target could make a most effective decoy against a radar-only attack. In addition, extensive use of cover, concealment and visual deception is likely to be employed.

Section 4

Electronic Warfare

Chapter 1 General Considerations
2 Tornado EW Equipment
3 Tactical Employment of EW
4 Electronic Interference with Tornado Transmitters
5 EMCON
6 LSDW

SECTION 4 - TABLE OF CONTENTS

CHAPTER 1 - GENERAL CONSIDERATIONS

Page Number
(within the Chapter)

THE IMPORTANCE OF EW........1

THE ELECTROMAGNETIC SPECTRUM........1

OTHER EW ASSETS........1
- Escort Jammers........1
- Stand-Off Jammers........1
- Wild Weasel........3

TACTICAL USE OF EW FOR SELF PROTECTION........3
- Manoeuvre........3
- Low Level Flying........3
- Employment of Self-Protection Devices........3

COUNTERING AD WEAPON SYSTEMS........3
- AAA Tactics........4
- SAM Tactics........4
- Interceptor Tactics........4

THE IMPORTANCE OF COMBINING COUNTERMEASURES........4
- Manoeuvre, Low Flying and Chaff........4
- Manoeuvre and Active ECM........6

CHAPTER 2 - TORNADO ELECTRONIC WARFARE EQUIPMENT

INTRODUCTION........1

RWE (ARI 23284)........1

RHWR (ARI 18241/2)........1
    - Trials PHASIA 5 and WELLER........2
    - Trial ALIGHT........2
    - Trial YOCKLETON 1........2

- Experience During Operation GRANBY........3
    - Aerial Blanking........3
    - Ambiguous Signals........3
    - Engineering and Installation Problems........3

BOZ 107 (ARI 23336)........3
- Chaff and Flare Programs........4
- Automatic Operation........5

SKY SHADOW (ARI 23246/3)........5
- Pulse Operation........5
- CW Operation........5
- Limitations........5
- Serviceability........6

CHAPTER 3 - TACTICAL EMPLOYMENT OF ELECTRONIC WARFARE

INTRODUCTION 1
    Low Level 1
    Lookout 1
    Sky Shadow 1
    Crew Co-ordination 1
    Chaff 2
    Manoeuvre and Chaff 2
    Manoeuvre and Flares 2
    Generic Counter 3
    Reheat 3
    Tactics Against PD Fighters 3
    AD Systems -General 3

EW TACTICS IN NON-VISUAL CONDITIONS 4
    Manoeuvring 4
    Manoeuvre - TF 4

EW EQUIPMENT UNSERVICEABILITIES 5
    RHWR 5
    Sky Shadow 5
    BOZ 5

CHAPTER 4 - ELECTRONIC INTERFERENCE WITH TORNADO TRANSMITTERS

GMR AND TFR IN AN ECM ENVIRONMENT 1
    Sky Shadow Jamming of TFR 1
    Mutual Effects of Chaff 1
    Ground Jammers 1
    GMR and Jamming 1
    TFR and Jamming 2
    Chaff Against GMR 2
    Chaff Against TFR 2

RT INTERFERENCE 2
    Codewords 3
    Anti-Jam Radio 3

CHAPTER 5 - EMISSION CONTROL (EMCON)

The Chapter comprises recommended EMCON procedures for each Tornado radio, radar, or EW equipment - the relevant items are highlighted in the left-hand margin of the Chapter pages.

CHAPTER 6 - LASER SENSOR DAMAGE WEAPONS (LSDW)

INTRODUCTION 1

SENSOR DAMAGE 1
    Laser Damage 2
        Dazzle 2
        In-Band Damage 2
        Out-of-Band Damage 2
        Structural or Catastrophic Damage 2

THE LSDW THREAT 3
  Overland Threat 3
  Maritime Threat 3
  Damage Effect 3

TACTICAL IMPLICATIONS 3
  Acquisition 3
  Crew Vulnerability 3

COUNTERS TO LSDW 4
  Active Protection 4
  Passive Protection 4
    Eye Patch 4
    Internal Reflections 4
    Aircrew Visor 4
    Laser Warning Receiver (LWR) 4
    Flash Visor 5
    Reflective Spectacles 5
    Night Vision Goggles (NVGs) 5

PILKINGTON OPTRONIC PROTECTION VISOR 5
  Anti Laser Eye Shield (ALES 1) 5
  Use of ALES 1 6

CONCLUSION 6

ANNEX A: RELATIONSHIP BETWEEN OUTPUT POWER, LASER TYPE AND DAMAGE LEVELS A1

INTENTIONALLY BLANK

CHAPTER 1 - GENERAL CONSIDERATIONS

THE IMPORTANCE OF EW

1.(R) The effectiveness of military forces in the modern world of advanced technology is increasingly dependent on the effective use of the electromagnetic spectrum. Defensive and offensive weapons, as well as their supporting command and control systems use electromagnetic systems which employ radio, radar, acoustical, optical, electro-optical, infra-red and laser technology in their operation. Military forces cannot fight effectively without the use of the electromagnetic spectrum.

2.(C) Many potential enemies possess considerable capability to operate in the electromagnetic spectrum and to affect the environment in which combat can occur; crews need to be fully aware of new systems that enter service. A description of ex-Soviet concepts and doctrine for the hostile use of the electromagnetic spectrum is contained in the document entitled Soviet Radar Electronic Combat (REC) held by station intelligence sections.

3.(R) An enemy is likely to depend upon tight command and control of its forces, coupled with destruction and disruption of friendly command and control capabilities and extensive use of manoeuvre and firepower, for the accomplishment of military objectives. Such actions depend upon an ability to control the electromagnetic environment. The control of this environment is as important to successful operations as weapons platforms and manpower.

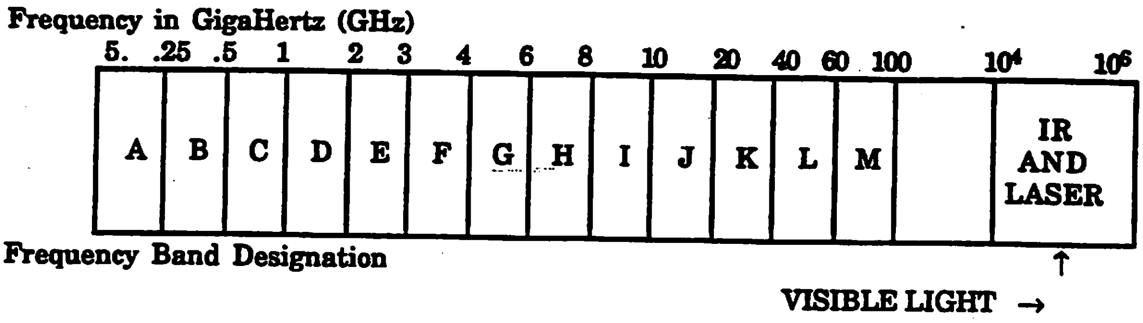
THE ELECTROMAGNETIC SPECTRUM

4.(R) The spectrum of electromagnetic energy can be said to cover frequencies ranging from below one hertz (one cycle per second) at the lowest end of the spectrum, through the frequency of light and beyond to gamma and cosmic rays. Users of the spectrum select various positions in it so that the physical characteristics which pertain to specific frequencies can be applied to achieve the desired aim; in general, the electronics engineer is concerned with frequencies from just below 10 KHz to about 100 GHz. (KHz = Hz x 10^3 and GHz = Hz x 10^9). Typical uses of the various frequency bands can be seen in Figure 4-1-1.

OTHER EW ASSETS

5.(R) **Escort Jammers.** Escort jamming (EJ) requires that the output of the escorting force shall provide coverage for itself and for the raiding force it protects against threat radars. The position and spacing of all aircraft involved will be a critical factor to obtain coverage of the main force and the jamming force, and to counter interception by Home On Jam (HOJ) techniques. Typical aircraft capable of this task are the EF-111 Ravens and EA 6B Prowlers.

6.(R) **Stand-Off Jammers.** Stand-off jamming (SOJ) may be mounted by a single aircraft carrying a number of jamming units or by a formation of aircraft. Coverage will vary widely according to jammer power, altitude, range, the nature of the jamming radiation used, and the target system under attack. The operational effectiveness of the technique will depend upon the depth of penetration required by the attacking force and the minimum distance from the threat at which stand-off jammers can be stationed with acceptable safety. Stand-off jamming may be employed against command and control communication links using for example EC-130 Compass Call aircraft or against radar systems using the same assets capable of escort jamming.



Frequency Band	Typical Usage
A	Radio Broadcasting Communications, VHF TV
B	Communications, UHF TV
C	Soviet Maritime Surveillance Radars
D	IFF, Nav aids
E	Surveillance Radars
F	Missile Guidance
G	Micro Wave Relay
H	Micro Wave Relay
I	Fire Control Radars (FCR's), Doppler Devices, AI Radars
J	Fire Control Radars, TFR, GMR
K	Fire Control Radars (AI, Mortar, AA)
L	Satellite Data Links
M	Millimetric Radars
IR AND LASER	Heat Sensing Devices: Laser Ranging and Damage Systems

Figure 4-1-1(R) - Electromagnetic Spectrum

TACTICAL MEMORANDUM NO 1

TORNADO GMR/ROLAND AMBIGUITIES

1. There has recently been an anomaly detected between the Tornado GMR and the HARM Targeting System (HTS) of the F16 C/Js in the Gulf theatre. In Jan 96 a pair of F16 C/Js reported indications of a ROLAND MG signal which appeared to emanate from the TALLIL BARLOCK EW site. As both F16s received the indications simultaneously they were within their ROE to prosecute a HARM attack. However, the Tornados they were escorting were between themselves and the perceived ROLAND, so no firings were made.

2. Subsequent analysis indicated a partial RF match between ROLAND MG and Tornado GMR, although the PRFs are quite different. In fixed frequency mode the GMR randomly selects one of 20 channels spread over 300Mhz when selected from "Standby" to "On". Occasionally, this random selection will fall into one of the top 2 ROLAND MG RF channels. However, if frequency agility were to be selected then the probability of matching the ROLAND channels would be much greater, and more frequent. Further analysis confirmed the error lies within the HTS PFM. The parametric lines for ROLAND MG within the PFM do not model the complex PRFs accurately enough, thereby producing the anomaly. Action is in hand for the HTS PFM to be changed but, in all probability, may take some time. Therefore, until a successful modification to the HTS has been confirmed it must be assumed that any aircraft equipped with HTS is liable to suffer from this anomaly.

3. Consequently, in the short-term, care must be taken to ensure adequate spatial separation between GR1 aircraft and HTS equipped aircraft is planned, if at all possible. Aircrew should be aware of the potential confliction and the likely distraction it may cause. Careful study of the Int picture will assist in deciding on the likelihood of encountering a ROLAND in the vicinity, and therefore the probability of any ROLAND MG display on the HTS being spurious or not. Obviously, a close working relationship with HTS operators will further assist in reducing the problem.

INTENTIONALLY BLANK

7.(R) **Wild Weasel.** The 'Wild Weasel' concept is to achieve air superiority by seeking out enemy radar systems that are a threat to friendly air operations followed by suppression or destruction of the systems. This includes land-based/shipborne SAM systems, gun-laying AAA radars and EW/GCI acquisition radar systems. Currently the only assets capable of this task are in F-4G and a limited number of F-16 aircraft of the US Air Force together with EA 6B Prowler aircraft belonging to the US Navy. In due course the ECR variant of the Tornado should also have this capability. (Note: RAF Tornado aircraft with ALARM cannot be categorised as 'Wild Weasel' assets as an enemy radar system does not have to be 'seen' by either the Tornado or the ALARM before the missile is fired.)

SEE TAC MEMO NO 1 ←

TACTICAL USE OF EW FOR SELF PROTECTION

8.(R) **Manoeuvre.** The maximum effectiveness from on-board self-protection countermeasure equipment will be obtained when their use is combined with appropriate tactics and/or evasive manoeuvres such as jinking and weaving. Particular attention has to be given to the antennae spatial coverage of aircraft warning and jamming equipment. On most aircraft, when an evasive manoeuvre is executed, the receiving/radiation pattern remains fixed relative to the aircraft axes and the degree of warning and protection can be reduced.

9.(R) **Low Level Flying.** High speed penetration at low altitude, preferably below the radar line of sight, greatly reduces the threat from enemy fighters and the probability of successful engagement by SAM, AAA and ground based jammers (GBJ). The aim at low level is to exploit terrain features to the full to avoid the defences. However there are some disadvantages in low level flying, namely exposure to small arms fire, reduced vertical manoeuvrability, limited visual acquisition of launched SAMs, more demanding navigation, difficult mutual support and degraded target acquisition.

10.(C) **Employment of Self-Protection Devices.** In general any type of emitter may inadvertently interfere with receivers within range. Thus, when deciding to activate a jammer, the degradation effect on friendly systems needs to be borne in mind. When flying over friendly territory active systems should be set to 'Standby', firstly to avoid such interference, and secondly to avoid presenting a hostile target to the defences. There will also be occasions when it will be advantageous to fly with ECM in 'Standby' over hostile territory to prevent high-lighting the aircraft. Because the RWR is a passive device there is no constraint on its use, but if any dispensing system has an automatic function crews should consider the use of Manual mode to avoid the unnecessary discharge of the limited number of expendables. If the tactical situation is favourable the dispensing of chaff and/or infra-red decoys should be withheld until the aircraft is under direct attack. Depending upon the geometry of the engagement a change in aircraft vector immediately upon activating chaff or flares can increase the effectiveness of the countermeasure against tracking radars, missile guidance techniques and, possibly, the projectile fuzing system.

COUNTERING AD WEAPON SYSTEMS

11.(C) The preferred counter to AD systems is to avoid them, and to do this successfully implies up-to-the-minute intelligence briefings. This principle may also hold good for penetration of friendly airspace. When airborne, crews will need to rely on visual appreciation and the threat warning systems that are carried by the aircraft. Low altitude and high speed may offer the best environment for the penetrator so that advantage can be taken of terrain masking. In most engagement situations consideration should be given to dispensing chaff to encourage guidance errors and early triggering of the weapon fuzes. It is also important that aircraft present low reflectivity aspect to the defences irrespective of whether the AD sensor is radar, IR or visual. Sun glint should be avoided and camouflage (of all kinds) is essential.

12.(C) **AAA Tactics.** AAA systems require continuous radar or optical input to the tracking computers so that aiming lead angle can be predicted. Jinking and weaving are useful manoeuvres against any automatically or manually aimed ground fire, preferably in conjunction with ECM. However, high angles of bank that expose large aircraft planforms to the radar or operator should be avoided. Similarly, rapid control inputs that do not significantly change the flight path of the aircraft serve no purpose. When confronted with AAA fire it is generally best, if possible, to manoeuvre away from the threat. A significant threat could arise from small arms fire (from calibres up to 14.5 mm) which is considered to be effective out to about 1,500 feet. The degree of threat to the aircraft will depend upon visibility, the mass and calibre of the small arms and the degree of tactical surprise that can be achieved by flying low and fast. Clearly if an AAA system is not individually aimed but forms part of an overall wall or 'barrage' which must be flown through, neither manoeuvre nor ECM will have any effect. Furthermore, the tactic of TOT compression will also have no effect; surprise is the best tactic to employ in this case.

13.(C) **SAM Tactics.** The rapidly changing technology inherent in SAM systems and the scarcity of information preclude hard and fast rules to counter SAMs. In a one-on-one situation some systems can be avoided by underflying the engagement envelope but in a multiple threat environment the crew will need to assess the highest priority to be dealt with and act accordingly. Details of enemy systems, such as the number of missiles that can be guided simultaneously, the acquisition-to-fire time, the re-load capability and the missile performance should be committed to memory. Jinking and weaving are useful manoeuvres combined with ECM, and if it is suspected that missile launch has occurred, chaff and where appropriate IRDs should be discharged. If a missile in flight is of the older and slower type it may be defeated by a late high 'g' turn towards it . More information on recommended tactics to be employed against SAM systems is given at Section 6.

14.(S) **Interceptor Tactics.** Modern interceptor aircraft possess high specific excess power and a high sustained rate of turn. Their radar equipment will probable have a pulse doppler mode which in turn will provide the aircraft with a look-down-shoot-down capability. The fighter will most probably possess a RWR, an angle-on-jam (AOJ) radar mode and a home-on-jam (HOJ) weapon. The weapons can be a mix of active and semi-active radar, passive IR and guns. The guided weapon can be expected to pose an all-round threat at low level. The current IR weapon is likely to be rear-quadrant capable to a range of 4 Km and double that head-on. As mentioned earlier the primary aim is to avoid the fighter, but if this is impossible the corollary is to avoid engagement. The considerations mentioned in paras 12 and 13 should be borne in mind when dealing with the fighter aircraft. As it is a mobile FCR, some success in breaking lock is likely if the victim can place itself at or near the zero doppler geometry, that is 90° to the AI radar boresight. More information on recommended tactics to be employed against fighters is given at Section 6.

THE IMPORTANCE OF COMBINING COUNTERMEASURES

15.(S) **Manoeuvre, Low Flying and Chaff.** Crews should be aware of the capabilities of a potential threat system and its methods of operation, and understand in detail what protection their own EW equipment is able to provide. This knowledge, together with a firm grasp of the most effective combination of tactics to employ, will enhance the success of the mission. The MACE series of trials highlighted the degradation effect that the combination of manoeuvre, low flying and the dispensing of chaff can have on a modern monopulse MTI FCR. Phase 1 of the Trial was conducted using A-10 and Jaguar aircraft flying at 150 ft agl and using manoeuvre up to 4'g'. The speeds used were 250 kn for the A-10 and 450 kn for the Jaguar. The FCRs were the HSA 4/41 Flycatcher and the Marconi ST 858. Figure 4-1-2 illustrates the improvement in survival that can be achieved when chaff dispensing and manoeuvre are combined. The example shown is the Jaguar fitted with Phimat dispensers on an offset profile against the ST 858 radar. The missile fly-out model used was the SA-8, with a lethal miss distance of 15 m. The percentage quoted in Table 4-1-1, which shows the number of missiles within the 15 m lethal miss distance, should not be construed as kill probabilities; no allowance having been made for:

a. Missile misfires.

b. Control, propulsion or guidance malfunction.

c. Fuzing failure.

d. Reload delays or limited missile availability.

e. Operational degradation factors.

Note: Although these factors do not allow the absolute percentage ratios to be used as kill probabilities, the percentage relative differences clearly show the value of combining manoeuvre and chaff.

Similar evaluations involving Tornado GR1 aircraft have also been carried out against different monopulse weapon systems. The most extensive evaluations were carried out during the CTTO PHASIA series of trials and culminated in Trial PHASIA 5 when the effects of manoeuvre and chaff against a SADS 8, an open loop SA-8 simulator, were assessed. While it was noted that chaff alone was insufficient to achieve break-lock unless the aircraft was flying tangential to the SADS 8, a missile miss distance in excess of 60 ft occurred on 35% of occasions when a non-manoeuvring aircraft dispensed chaff compared with only 9% when the aircraft did not dispense chaff. However, a combination of manoeuvre and chaff generally induced small tracking errors during the early stages of the turn away from the SADS 8 and frequently caused break-lock when tangential to the threat. The timing of the initiation of the chaff dispensing

CONDITION	Percentage missiles within 15 m
Aircraft straight and level, no chaff	98
Aircraft straight and level dispensing chaff	95
Aircraft manoeuvring, no chaff	60
Aircraft manoeuvring and dispensing chaff	15

Table 4-1-1(C) - Missiles Passing Within Lethal Miss Distance during the break-lock manoeuvre was not critical, so long as the chaff was being released when the aircraft was tangential to the TTR. A subsequent 'quick look' trial against an ex- East German SA-8 (Trial WELLER) validated the results from PHASIA 5. A further 'quick look' trial. which involved flying Tornado GR1 against Roland (Trial ALIGHT), also produced similar results. Chaff and manoeuvre is assessed as causing TTRs, including those of SA-3 and SA-8 systems, to break-lock on several occasions during RAF missions in Operation GRANBY

16.(S) **Manoeuvre and Active ECM.** Trial GUARDRAIL Phase 3 is a report on flight testing of the operational effectiveness of the Buccaneer ECM pod. The trial was conducted using Buccaneer aircraft flying at 500 kn at 1,000 ft above radar height. Results against the LOW BLOW radar illustrate the effectiveness of combining active ECM with manoeuvre (Table 4-1-2). The percentages quoted are subject to the qualifications outlined in para 15. Care has to be taken that active ECM works in favour of the emitter and not against it. For example, Trial PHASIA 5 highlighted again that any attempt to jam the SA-8 TTR with the Skyshadow pod is likely to cause a beaconing effect and improve the accuracy of the radar tracking. Similarly, Trial WELLER showed that the Skyshadow jamming techniques currently available will also assist Roland to track the emitting aircraft. However, PHASIA 5 did identify that jamming a SA-8 TAR with Skyshadow could, under certain circumstances, prevent the TTR achieving a lock; more information on this aspect is given at Section 6.

CONDITION	Percentage missiles within 15 m
Aircraft straight and level, no chaff	100
Aircraft straight and level with active ECM	33
Aircraft manoeuvring	71
Aircraft manoeuvring with active ECM	20

Note: Aircraft manoeuvre was limited to ±30° of datum track.

Table 4-1-2(S) Missile Passing within 150 ft Miss Distance

CHAPTER 2 - TORNADO ELECTRONIC WARFARE EQUIPMENT

INTRODUCTION

1.(U) The Tornado Electronic Warfare (EW) equipment comprises the externally mounted Sky Shadow ECM pod and the BOZ 107 chaff and flare dispenser together with the Radar Homing and Warning Receiver (RHWR). A limited number of aircraft have the earlier Radar Warning Equipment (RWE) instead of the RHWR.

2.(S) The results of Trial PHASIA 3 demonstrated that the RWE required operator training to determine correctly the threat, particularly since the TWP will often indicate several threats for a single locked-on vector. As the number of aircraft with RWE is so small and largely confined to the TTE, the equipment will not be covered here.

RHWR (ARI 18241/2)

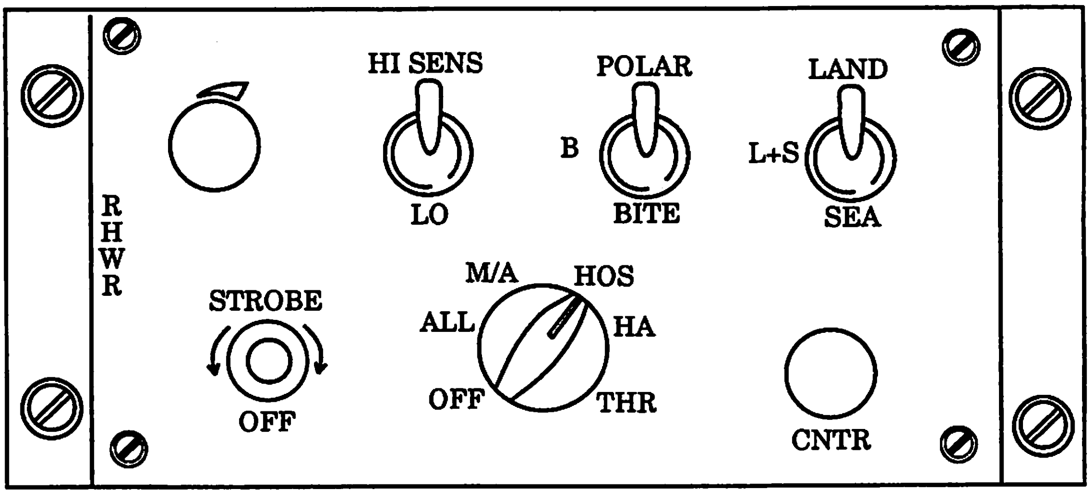


Figure 4-2-1 (R) - RHWR Control Unit

3.(S) The RHWR is a scanning super-heterodyne receiver. The equipment operates over a frequency range 0.7 to 18.0 GHz and is capable of detecting and displaying MG, pulse and CW signals. The equipment has 2 audio alerts to indicate lock-on and missile guidance; the layout of the rear cockpit CU is shown in Fig 4-2-1.

> **Warning: The function of the switches on the CU is software controlled and therefore the labelling by each switch position is at best largely irrelevant and at worst confusing. It is therefore essential that crews familiarise themselves with the documentation issued by EWOSE with each Pre-Flight Message (PFM).**

4.(S) The performance and anomalies of RHWR are well documented in the CTTO reports following Trial EPIGONE and Trial PHASIA 4. In addition, information on RHWR performance against SA-8 is given in the Trial PHASIA 5 and WELLER reports, and performance information against Roland is given in the Trial ALIGHT report. The Trial YOCKLETON reports provide some information on the performance of the equipment against the SLOT BACK radar fitted to FULCRUM. Some of the more general comments are given below.

a. **Trials PHASIA 5 and WELLER.** During PHASIA 5 the performance against the SA-8 simulator (SADS 8) was not good and the delay before warning of missile guidance was particularly poor. The performance against the TAR was further degraded if Sky Shadow was transmitting. These findings were validated in early 1991 during WELLER when limited flying was carried out by the SAOEU against an ex-East German SA-8.

b. **Trial ALIGHT.** Trial ALIGHT was carried out in early 1991 against several Roland systems deployed on Nordhorn Range. The performance of RHWR against the TAR was poor due to the surveillance radar dwell strategy. The performance against the TTR was improved by changing the MEZ value in the PFM from 5 to 8 km and lowering the alarm sensitivity to overcome a polarisation incompatibility problem between the Roland TTR and RHWR aerials. After changes to both the MEZ value and the sensitivity, at 1,000 ft, the TTR was achieving a lock at approximately 7 nm and detection of the TTR by the RHWR was occurring at 6 nm with coincident audio alarms (trimphone); first practical missile launch was at 4.5 nm. At 250 ft, the TTR achieved lock at 5.1 nm and the RHWR gave first indication of the TTR with a coincident audio warning at 4.5 nm with first practical missile firing at 4.1 nm (all quoted ranges are average figures). Indications of MG were rarely seen at either height. The results of the trial highlights the necessity to initiate an evasive manoeuvre with chaff as soon a Roland threat warning is received, especially when at 250 ft or below.

c. **Trial YOCKLETON 1.** In late 1990, Tornado GR1 of the SAOEU flew against an ex-East German FULCRUM as part of Trial YOCKLETON 1; bad weather limited the data obtained. RHWR indications were generally as expected with SLOT BACK detected at 50 to 55 km in the head-on situation (FULCRUM flying 1000 ft above the Tornado). The indication of the threat (trimphone with flashing tag) appeared shortly after SLOT BACK achieved a lock; both high and medium PRF signals were seen. On one mission, full command guidance (CG) indications ('Kojak' with 'FULCRUM Ill') were seen at or about the same time the FULCRUM simulated a head-on firing of an ALAMO missile. The aircrew received threat indications only on the second mission with occasional listings on page zero of CW/ICW; no CG indications were seen despite simulated front hemi-hemisphere firings of ALAMO. No reason was apparent for the differences between the 2 missions. The lesson appears to be that any indication of FULCRUM CW/ICW on RHWR may indicate the presence of CG despite the lack of 'Kojak' audio!

5.(S) The position of the sensitivity and display selector switches will be determined by the stage of flight and by crew preference. At 'HI SENS' and at medium altitudes the equipment receives many signals, often reaching the maximum number that can be displayed. At low level and in a benign environment 'HI SENS' could provide early detection of integral SAM acquisition radars. Setting the sensitivity from HI to LO reduces the surveillance sensitivity by 30 dB (Note: This has no effect on threat warning dwells). At any position other than 'OFF' the CRT will display threats but the 'HOS' position should give early detection of most hostile emitters. However, there may be too much information presented on the display and a change to 'THR' may be necessary.

6.(S) The scenario selection within the PFM is via the 'LAND/SEA' switch which is on the rear cockpit CU only. The switch currently determines whether RED ('LAND'), RED+BLUE ('LAND+SEA') or BLUE ('SEA') emitters are displayed. Significantly, however, any emitter which meets the programmed threat criteria within the threat warning dwell strategy of the scenario selected will trigger the audio warnings regardless of the scenario selected. For example, if BLUE is selected but a RED emitter is detected within the BLUE threat warning dwell strategy, an audio warning will be given and the BLUE scenario tell-back will flash; however, no vector or tag will appear unless RED is selected by the navigator.

7.(S) **Experience During Operation GRANBY.** Experience during GRANBY highlighted 3 main problem areas: aerial blanking particularly at medium/high altitudes, susceptibility to ambiguous signals, and engineering and installation problems.

a. **Aerial Blanking.** Prior to GRANBY the RHWR aerials were known to suffer a degree of blanking at low level when the aircraft was banking (Trial PHASIA 5 report refers). However, at medium or high levels the blanking problem for ground emitters is considerably worse because the obscuration effects caused by wings, fuselage and fuel tanks must all be considered. In theory, an aircraft could take almost 60 sec, when flying at 20,000 ft and 500 kn, to clear the blanking shadow from the fuselage alone. The problem is not thought to be as bad as this in practice and trials are due to take place in the near future to investigate the full extent of this problem.

b. **Ambiguous Signals.** The IFF Mk XII caused spurious indications on the RHWR which appeared, in part, to be caused by an incorrect suppression pulse on the host aircraft. In addition, IFF signals from other aircraft in close proximity also gave rise to spurious detections. Modification to the IFF parametric data in the PFM failed to resolve the problem. Furthermore, some of the spurious detections were coincident with known threat radar frequencies and therefore spurious signals were ambiguous and constantly mis-identified as a threat.

c. **Engineering and Installation Problems.** Lastly, the serviceability of the equipment going in to theatre was poor and much time had to be spent rectifying such problems as cross-connected Gore cables and lack of sensitivity caused by damaged cables; some problems were still being investigated well into the period of hostilities! The morale from this last point is clear: treat EW equipment in peacetime as you would in war. If the equipment does not work correctly - **get it fixed.**

See overleaf for BOZ 107

BOZ 107 (ARI 23336)

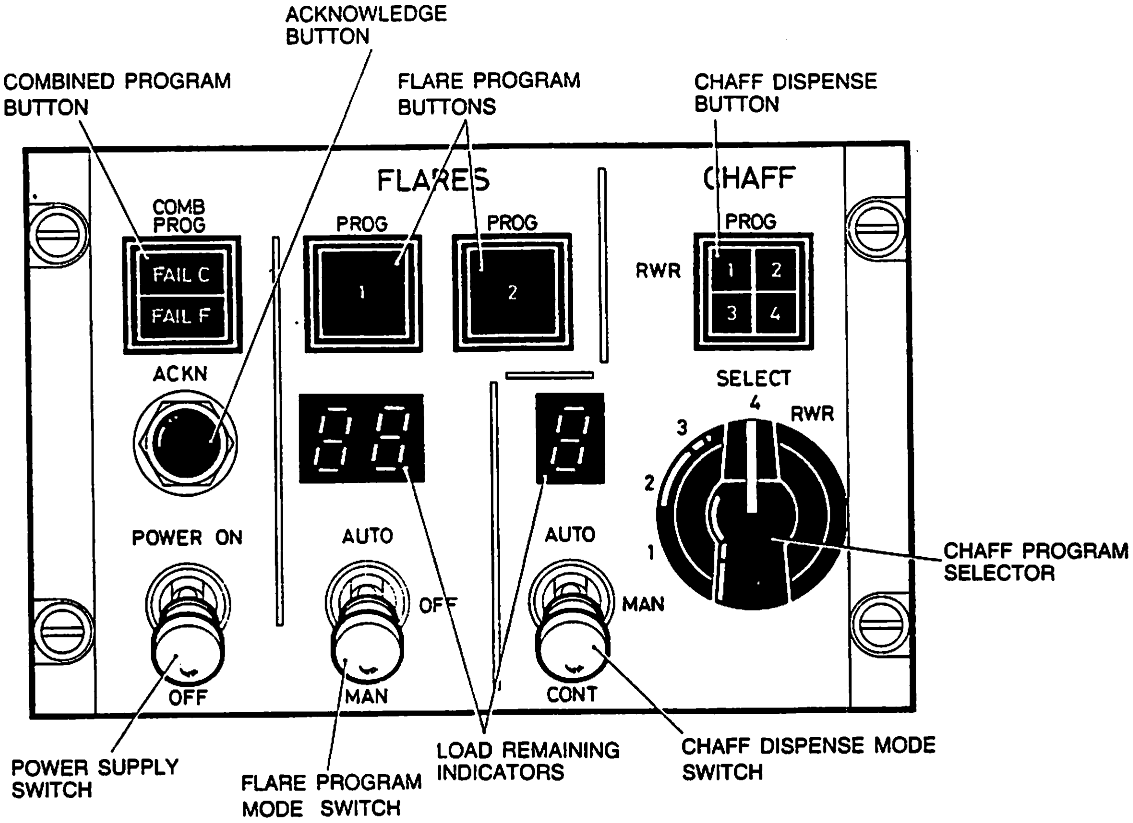


Figure 4-2-2 (R) - BOZ CU

8.(S) The BOZ 107 CFD is carried on the right-hand outboard station. The BOZ control panel, shown at Figure 4-2-2, allows the use of chaff or flares independently or in combination (Combined Program (CP)) with programs set on boards in the nose electronics unit. The basic fit for this facility is for initiation from the rear cockpit only; however, some aircraft have a modification which also allows initiation from the front cockpit.

9.(S) The flares, or IR decoys (IRDs), procured for the Tornado GR1 are the RARDE developed Wallop CM55. The unit is a cartridge containing two separate assemblies capable of independent ejection. Fourteen cartridges are carried, each weighing 650 grams. The flares are of Magnesium/Teflon (Mg/Te) construction with a rise time to peak power of 0.25 to 0.5 secs. The flares emit considerable IR energy, but at 1.5 microns Mg/Te burns at less than the peak wavelength of aviation kerosene. Because of the need to avoid the flares hitting the taileron they are ejected outwards and slightly down. Consequently, a turn to starboard would not increase the separation between the aircraft and flares. Turns to port should, therefore, be made whenever possible.

10.(S) The BOZ 107 dispenser can hold a maximum of 600 packs of broad-band chaff weighing about 80 kg. The chaff, manufactured of aluminium coated glass, can be dispensed either continuously or using one of 4 selected programs. With a dispense rate of 5 mm/sec, chaff could be continuously dispensed for over 5 minutes, or a short program could be initiated over 50 times. The operation of the BOZ mantle and the dispensing of chaff into the venturi takes a finite time and on the first initiate from a fully loaded pod up to 0.5 secs will elapse before chaff is dispensed into the airflow. The chaff venturi should, therefore, be primed by initiating the shortest program shortly after take-off; the programs can be stopped and reset by selecting the power switch OFF and then ON.

11.(S) **Chaff and Flare Programs.** The 4 chaff and 2 flare programs contained in the latest BOZ data set at the time of publication - TOR07 - are shown in Table 4-2-1 below. Chaff is a finite resource; continuous dispensing is not recommended because it gives no operational benefit. The contents of each program can be changed; therefore, it is recommended that Wing/Sqn EWOs check whether TOR07 has been superseded and, is so, ensure they are aware of the contents of the programs in the current data set.

Chaff Program	Rate (mm/sec)	Run Time(sec)		Use
1	5	17		IMC turns Mini loft attacks
2	5	8		Visual counters/breaks
3	5	23		Loft attacks
4	20	1		AI breaks. CP
CONT	5	Continuous		Don't!
Flare Program	**No**	**Interval (sec)**	**Time(sec)**	**Use**
1	1	-	-	Training only
2	3	0.25	0.5	IR missiles, Loft, CP

Table 4-2-1(S) BOZ Data Set TOR07 - Programs and Recommended Use

18.(S) **Automatic Operation.** Chaff can be dispensed automatically from the BOZ pod. In the fully automatic mode the chaff program selector is set to RWR and the chaff mode switch to AUTO to allow initiation of one of the 44 pre-set chaff programs upon detection of certain radar tracking signals by the RHWR. In the semi-automatic mode the program selector remains at RWR, but MAN is selected on the mode switch. Upon detection of tracking signals, the appropriate chaff program caption flashes on the Chaff Dispense Button and this program is initiated by pushing the button. However, the automatic and semi-automatic functions of the BOZ pod have not yet been evaluated nor cleared for use. AL1

SKY SHADOW (ARI 23246/3)

19.(S) The Sky Shadow ECM pod is a software-programmable auto-responsive noise and continuous wave (CW) repeater jammer operating in two overlapping frequency bands. The low band operates in the frequency range of 5.0 - 9.4 GHz and the high band covers 9.15 -16.4 GHz. The pod is able to jam simultaneously up to two pulse radar threats in each band concurrently. It can also produce repeater jamming of CW radars. For practical purposes Sky Shadow's antenna polar diagram comprises solid cones of 60° semi-angle directed fore and aft and centred on the pod axis. The software is designed to ensure that radars associated with the greatest threat are countered first and that threats ahead of the aircraft have a higher priority than those behind.

AL1 (MS)

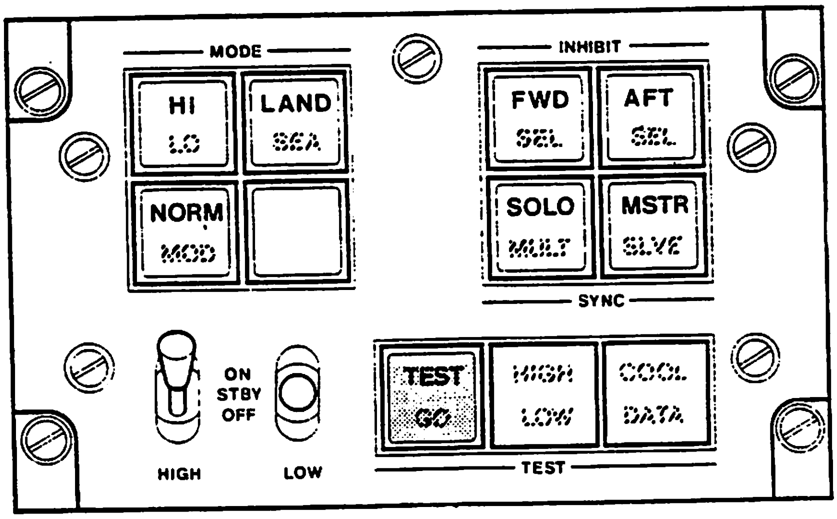


Figure 4-2-3 (C) - Sky Shadow Control Panel

20.(R) The Sky Shadow control panel is shown at Figure 4-2-3.

> **Warning: The function of the mode buttons on the control panel is software controlled and therefore the labelling on each is at best largely irrelevant and at worst confusing. It is therefore essential that crews familiarise themselves with the documentation issued by EWOSE with each Pre-Flight Message (PFM).**

21.(S) **Pulse Operation.** The pod analyses the received signal and determines its identity by frequency and PRI. A pre-determined signal amplitude is used to define radar lock-on and to initiate Sky Shadow jamming which is transmitted at full transmitter power. The mode buttons on the control panel can be used to alter the program.

22.(S) **CW Operation.** The 2 panniers on the pod each contain a CW receiver and fore and aft antennae assemblies, the left pannier for high-band operation and the right pannier for low-band operation. Signals received by the panniers are fed through band-pass filters in the pod which cover the frequency bands of CW threat emitters. Four CW filters are available within the pod and these are tuneable to cater for possible variations in threat frequency. CW signals are identified by frequency only but the deception techniques used do not necessarily use full transmitter power.

23.(S) **Limitations.** Sky Shadow produces high power outputs which will effectively deny range information to a variety of pulse radar systems. Unfortunately, many systems do not require aircraft range information and their angle tracking techniques can be aided by the presence of jamming. Against such systems Sky Shadow has little or no capability. However, relatively simple acquisition radars can be prevented, by Sky Shadow noise jamming, from designating targets for tracking radars as was amply demonstrated during PHASIA 5 and WELLER. Some current operational PFMs contain a noise counter to the LANDROLL TAR as part of the recommended tactic to defeat SA-8.

24.(S) **Serviceability**. The in-Service serviceability of Sky Shadow has been shown to be poor with the mean time between failures (MTBF) significantly less than the time stated in the specification for the pod. This problem has been compounded by the unreliability of the BITE performed by the pod and limitations in the ground test equipment, eg failures within the pod are not always identified during bay checks. In an attempt to rectify this situation CTTO managed Trial OVERPRAISE which investigated whether an airborne check could provide an indication of pod serviceability. The results from the trial were encouraging and a schedule has now been established to fly pods through the Polygon EW Range (Spadeadum Range is currently unsuitable for this task due to non-availability of some essential ground-based equipment). During GRANBY crews considered the Sky Shadow pod a critical go/no-go item for a war sortie; however, the serviceability of the pods was, in general, very poor when initially deployed to the Gulf and considerable time and effort was required to bring many up to a satisfactory state. **It is essential that every effort is made to keep pods serviceable during peacetime!**

INTENTIONALLY BLANK

CHAPTER 3 - TACTICAL EMPLOYMENT OF ELECTRONIC WARFARE

1.(U) The primary aim for Tornado crews is to deliver their weapons on the target and return home safely. Electronic warfare (EW) is a means to achieve that aim and not an aim in itself. The employment of the Tornado EW equipment and the development of tactics is well established and many trials and exercises involving EW training have been carried out. This Chapter collates the information gained over the years the Tornado has been in service and gives advice on the tactical employment of EW by Tornado crews.

2.(S) Although the low level gap is closing, there is still sufficient room for well trained aircrew to exploit the low level weaknesses of air defence systems. Generally, the abilities of such systems are degraded when countering targets that are flying fast and low. Furthermore, no system is able to engage targets that cannot be seen, either visually or on radar; therefore there is no substitute for terrain masking. Finally, no weapon system is perfect and missiles will suffer problems, before and after launch, such as guidance malfunctions or premature fuzing. A good radar lock does not necessarily mean a successful engagement!

3.(S) Lookout remains the primary warning of attack on an aircraft; electronic lookout using the RHWR is merely an extension of this principle. The RHWR needs to be scanned visually to detect Early Warning and other radars. The visual scanning of the RHWR should thus be part of the regular lookout scan carried out by both crew members. In a dense radar environment, or at times of high workload, many of the lower priority threats can be removed from the displays by selective switching. Whenever possible, crews should use their RHWRs to avoid overflying all air defence sites, even SA-2, to avoid unnecessary exposure to small arms, eg AAA and SA-7/14/16.

4.(R) Generally, once the first lock-on by a threat system has been detected by the RHWR, the Sky Shadow pod should be selected to ON in both bands (if not already ON). For those threats the pod can counter, it is important to keep the threat vectors inside Sky Shadow pod aerial coverage; these sectors may be marked on the CRT displays for easy reference. The initial turn to put the vector into pod aerial coverage may be towards the threat, followed by a sharp turn away to ensure that the vector is quickly transferred from front to rear Sky Shadow aerials whilst maintaining a mean line of advance. The initial turn should also be used to deploy chaff in an attempt to break radar lock. Chaff may be re-initiated at any time but its effectiveness is markedly increased if it is combined with manoeuvre.

5.(S) For much of the time, crews of RHWR-equipped aircraft will be able to see all the many threat vectors. At this stage crews will be carrying out two quite distinct tasks. The pilot will be concentrating almost solely on maintaining ultra low level while carrying out jinking in a random manner, or as called by the navigator, in response to specific threats. Meanwhile, the navigator should be concentrating on lookout for the simultaneous launch of a radar missile and reception of its associated CG signals. In order to have any chance of defeating the SAM the crew must see its launch; they are unlikely to detect the missile in flight after the boost phase. After launch the crew should attempt to continue terrain screening while maintaining the vector inside Sky Shadow aerial coverage for those threats the pod can counter. Older larger SAMs, such as

SA-3, may be defeated by aircraft manoeuvre; however, newer missiles are likely to be able to out-manoeuvre even an unladen Tornado. Once the crew have decided that the missile is guiding towards them they should consider stores jettison ready for a missile break. The break should be started as the missile approaches $1^1/2$ - 2 nm and should be carried out up and towards the missile using all the available aircraft energy. It is important to remember that a break, that does not defeat the missile aerodynamically, may still cause radar break-lock and have the same effect, ie the missile will not hit the target. The ECM and BOZ pods, and AIM-9 missiles should be retained as their jettison would bring little benefit in turning performance and they may be needed for protection on the return to base.

6.(S) The results of Trials PHASIA 3 and 5, Trial ALIGHT and the NATO Trial MACE III highlighted the benefits that can be gained from using chaff combined with manoeuvre. The use of chaff by an aircraft constrained to fly straight and level would have limited value but may degrade radar tracking performance. Economic chaff programs should be used to avoid over saturation of chaff clouds; this particular effect was noted on Trial PHASIA 3. All these trials, along with Trial PHASIA 4, noted a degradation in radar performance caused by 'old' chaff, ie chaff previously dispensed and still airborne or lying on top of vegetation, but it is impossible to plan for its effect.

7.(S) Modern monopulse and pseudo-monopulse radars are particularly resistant to ECM but can be defeated by the use of chaff. Trials have showed that a turn of at least 2g, to put the aircraft tangential to the FCR while dispensing chaff (and most importantly ensuring chaff is being dispensed at the tangent), should produce radar breaklock. (Note: while Trial MACE III found that a break-lock was easier to achieve on a turn towards the radar, Trial PHASIA 3 demonstrated that this tactic is invalid against radars, such as the SA-8 TTR, that are capable of tracking the leading edge of the response). The SA-8 counter can be further enhanced, in some circumstances, by using Sky Shadow to jam the system's TAR. Break-lock was achieved on several occasions against SA-3, SA-8 and Roland on operational missions during GRANBY when chaff and manoeuvre were employed. The counters to radar guided SAMs are detailed in Section 6 Chapter 2 of this Manual.

8.(S) During Trial DECLAMATION, it was shown that a successful tactic to counter the SA-13 was to release 3 flares at 2 sec intervals and manoeuvre to reduce the sight-line rate. The tactic was designed to allow the missile to recognise that flares were present, while the long duration pattern was intended to keep the seeker in memory while the aircraft manoeuvred. However, the pattern was not effective against the AAMs tested in Trial ADDIS against the Tornado F3 which included AA-7D and AA-11. The results from this trial can be read across to the Tornado GR1/1A and showed that the optimum flare sequence to counter both the AA-7D and the AA-11 was 3 flares at 0.25 sec intervals. Idle/idle should be selected and, in general, a break towards the threat initiated and the flares dispensed (plus chaff in case the missile is RF-guided or fuzed). Ideally these procedures should be carried out as soon as a launch is detected; however, as an AAM may be impossible to see in flight, they should be carried out as soon as a fighter is seen to approach missile launch range. Both the short interval flare sequence determined during Trail ADDIS and single flares were subsequently evaluated against SA-13, SA-14, SA-16, basic Stinger, AIM-9L and AIM-9M during Trial RYE. The trial included dispensing flares from a Tornado GR1/1A in straight and level flight. Single flares decoyed the SA-14 and the SA-16; the latter for all angles except when within 15° of the 6 o'clock. The sequence of flares was required to afford protection against the basic

Stinger, SA-13 and AIM-9L although, again, there were some limitations from a stern engagement with the latter 2 missiles. Flares did not consistently protect the aircraft against the AIM-9M. The first impression report considered that the vulnerability near the 6 o'clock against SA-13, SA-16 and AIM-9L would be overcome by the addition of a break manoeuvre. Therefore, the tactics referred to in the previous paragraph to counter IR AAM, together with a flare sequence of 3 flares at 0.25 sec intervals, should be used to provide a generic counter to both the IR AAM and IR SAM; the tactics are described in detail in Section 6 Chapter 2.

9.(S) **Generic Counter.** The generic counter will defeat all but the most modern seekers (eg AIM-9M) and advanced flares are currently being developed under OER2/89 to provide protection against these threats.

10.(S) **Reheat.** The use of reheat may be necessary during other stages of the sortie, particularly to regain formation position or the time line. After crossing a FLOT whenever reheat is used, the pilot should warn the navigator who should deploy flares and watch for an IR SAM or AAM launch. Flares should always be accompanied by manoeuvre, which ideally should be to port to increase the separation between the aircraft and flares. During loft profiles a flare program should be initiated before selecting reheat. While fuel considerations may limit the use of reheat, crews should also be prudent in the use of reheat because of the associated use of flares.

11.(S) **Tactics Against Fighters.** The tactics to be employed against ex-Soviet fighters are also described in Section 6 of this Manual. The aim of these tactics is to avoid giving the fighter an opportunity to use AAMs. The use of Sky Shadow counters against older ex-Soviet AI radars is not recommended as these counters are unproven. Furthermore, radar guided AAMs generally have good HOJ capabilities although the use of radar guided AAMs from the earlier generation of fighters such as FISHBED and FLOGGER aircraft at low level is unlikely. IR guided AAMs from all types of fighters are a threat to low flying Tornados. However, the use of manoeuvre, flares and chaff, as discussed in paragraph 8 above, should reduce their effectiveness and offer complete protection against all but the latest AAMs - providing their use is timely! Chaff and flares should be selected using the CP button which in TOR07 gives Flare Program 2 and Chaff Program 4.

12.(S) **Tactics Against PD Fighters.** During the 1980s the Warsaw Pact introduced pulse doppler (PD) techniques into their air defence systems. By turning to be tangential to the threat, prior to reversing to track progress, Tornado crews may degrade a PD fighter's ability to engage beyond visual range and may even cause the radar to lose lock. This manoeuvre reduces the doppler return from the Tornado so that it merges with the ground return, ie puts the Tornado into the "doppler notch". Chaff should be used during the manoeuvre since, although its effects have yet to be quantified, chaff does exhibit some doppler qualities and may be successful in seducing the radar lock away from the aircraft. It is most likely that after loss of lock the fighter will quickly re-acquire, and the process may need to be repeated several times. This procedure was used against FULCRUM with some success during Trial YOCKLETON 1.

13.(U) **AD Systems -General.** When threatened by air defence systems, the crew must counter the threat as the highest priority task at that time; even for example, if the aircraft must leave a 'SUPPLAN M' type routeing system.

EW TACTICS IN NON-VISUAL CONDITIONS

14.(S) The preceding paragraphs of this Chapter concentrate on the tactical employment of EW by Tornado crews but, generally, in a visual flying environment. Tornado crews will most probably undertake the majority of their wartime flying using the TFR at night, in IMC, or both. Although it may be possible to see a missile launch at night, other fires could mask the flash of motor ignition. Furthermore, it will probably be impossible to detect the missile in IMC or after the boost phase. Consequently crews will place greater reliance on their EW equipment and the tactics they can use through the TF system. Moreover, both crew members, but particularly the pilot, will be able to devote more time to the RHWR than they could while flying visually.

15.(S) **Manoeuvring.** Although the threat from optically guided systems and IR missiles is greatly reduced in non-visual conditions, so is the manoeuvre that can be employed by Tornado crews. With adequate early warning from the RHWR, a Tornado could be manoeuvred to counter just one threat system. Unfortunately, the autopilot has a finite reaction time and limited manoeuvre capability and a Tornado will be unable to react quickly enough to a series of threats. The early CTTO Trial GUARDRAIL indicated that even a gentle weave, such as might be accomplished by a Tornado in TF heading hold, will cause a noticeable degradation in the performance of older threat radars. This random weave should be accompanied by the dispensing of chaff, and flares should be deployed whenever reheat is used.

16.(S) **Manoeuvre - TF.** The threat to low flying Tornados from older generation ex-Soviet manufactured fighters is negligible in non-visual conditions, but newer fighters, such as FULCRUM and FLANKER, pose a greater threat to Tornados in automatic terrain following (ATF) flight. Similarly, newer SAM systems will require greater manoeuvre to counter than is presently possible in ATF flight. Trials PHASIA 5 and ALIGHT showed that against more sophisticated SAM systems, eg SA-8 and Roland, it is essential to manoeuvre with at least a 2g turn to put the threat on the beam (and dispensing chaff when approaching and on the beam). Over flat terrain, the pilot could employ a hard climbing turn to achieve the tangent to the fighter as quickly as possible; low level could be regained, after radar break-lock, using the ATF system. This technique may need to be repeated several times and would require considerable forethought and crew co-operation before it could be accomplished safely. Against modern ground defences (SA-8 and thereafter) this tactic would bring just fleeting respite as the aircraft would then be exposed to other threat systems. The ability to carry out a hard turn using the E-scope to maintain terrain clearance will require considerable practice, but could be a successful counter to newer AD systems. In areas of flat, or only mildly undulating terrain, some thought should be given to using Radar Height Hold (RHH) along with Heading Hold. This allows a greater turn rate whilst maintaining low level. Areas likely to be of use for RHH, particularly crossing the FLOT and on the target run, should be noted during planning and could be marked on the map for easy reference. Until the advent of NVGs, FLIR and effective electronic counters, Tornado crews must consider most carefully their reactions to modern threat systems whilst in ATF flight.

> **Note: All of the techniques described at paras 16 are prohibited by the Release to Service, Command Air Staff Orders, or both, and should not be attempted until permitted as part of a peacetime VFR training programme.**

EW EQUIPMENT UNSERVICEABILITIES

17.(U) EW equipment can no longer be considered additions to attack aircraft, but rather as an integral part of their systems. Without the means to detect and defeat hostile threats, aircraft attrition rates are likely to be high. Unless directed by command, crews may have to consider carefully whether to take-off without their RHWR, Sky Shadow and BOZ pods.

18.(S) **RHWR**. Initial in-Service impressions were that the RHWR BITE was too sensitive and often indicated failures that were not apparent to the crew; many of these failures have now been eliminated. The failure of the low band should present least operational effects although the system may fail to detect MG signals. Failures in the high band (6.0 - 18.0 GHz) could cause loss of warning of all the major threat signals. Following a complete failure of the RHWR both bands of the Sky Shadow pod should be selected to 'ON' at the Early Warning line or when the MULT light on the Sky Shadow control panel illuminates. The illumination of the MULT light indicates that the pod has recognised a threat for which a counter is included in the PFM. To counter other threats the crew should make random, but not continuous, heading changes while dispensing chaff. If conditions permit, they should maintain the look-out for SAM launches and monitor other aircraft actions (BUSTER, WIDEN etc) to determine the presence of fighters.

19.(S) **Sky Shadow**. Although the Sky Shadow pod has an integral cooling system it heats up quickly on the ground, so ground running should be kept to a minimum. Some failures of either pod band may be cleared by a reset of the power switch. Experience suggests that the BITE is unreliable, and even after an indicated band failure the pod may still react in the failed band. A total failure of the pod, or of one of the bands, will make the aircraft more vulnerable. However, the threats countered by the pod are older generation and their effectiveness can be degraded by chaff and manoeuvre. The crew should, therefore, manoeuvre the aircraft and dispense chaff when a threat radar achieves lock-on. If the COOL light illuminates the pod should be selected to OFF, prior to the aircraft crossing the Early Warning line. At this line the pod should be selected to STBY (to allow about three minutes warm-up) for FEBA penetration. If the fault persists, the pod should be used as required until it fails completely. The illumination of the DATA light indicates that the pod is operating in the reversionary mode. In this mode the pod will react to all emissions, even from friendly systems, received through the forward aerials. One of the air defence criteria for the engagement of targets is the presence of ECM, consequently a Tornado jamming friendly air defences could be engaged by friendly systems. The crew will, therefore, need to monitor the RHWR and the pod to prevent pod stimulation by friendly air defences.

20.(R) **BOZ**. Failure of one or both parts of the BOZ pod would impose considerable limitations on a Tornado crew. The loss of the flare capability would reduce the crew's freedom to use reheat, while the loss of the chaff facility would increase the aircraft's vulnerability to newer radar guided missiles for which there is no Sky Shadow counter. Remember, the amount of chaff and flares contained in the pod is finite!

INTENTIONALLY BLANK

CHAPTER 4 - ELECTRONIC INTERFERENCE WITH TORNADO TRANSMITTERS

1.(U) Tornado crews should expect their aircraft systems to be subjected to both deliberate and accidental interference. This chapter offers some advice on the use of the GMR, TFR and radio in an ECM environment.

GMR AND TFR IN AN ECM ENVIRONMENT

2.(S) **Sky Shadow Jamming of TFR.** Early studies indicated that, because the range of GUNDISH radar frequencies covered the TFR frequency range, a Sky Shadow response to a GUNDISH radar could also cause interference to the TFR. The 'MOD' button on the Sky Shadow control panel was, therefore, employed to prevent Sky Shadow reaction at TFR frequencies. This is achieved by designating as friendly those frequencies that are common to both GUNDISH and TFR. Because of the overlap, it was thought that in TF trail formations Tornado TFRs could trigger Sky Shadow to give TF jamming. In-service experience with live Sky Shadow pods has failed to confirm the problem. The TF frequency agile mode should be selected on war missions only if jamming is experienced.

3.(S) **Mutual Effects of Chaff.** Chaff is primarily a self-protection device which should be used whenever it is required, although it may cause problems for following aircraft. During the penetration phase of a mission Tornado aircraft are unlikely to be following exactly in line astern and they will have freedom to manoeuvre around chaff that may be seen on the E-scope. On the target run, the effects of chaff are more likely to be experienced as crews are less likely to manoeuvre their aircraft. If the spacing between aircraft is greater than 90 seconds, the majority of chaff dispensed by an aircraft flying at 200 feet may have fallen to the ground before a subsequent aircraft reaches the same position. (This figure is based on the manufacturer's advice). Of similar concern is the effect that the chaff may have on the GMR by obscuring on-track offsets, or even the target. Crews will need to consider these effects in their selection of offsets and the spacing of aircraft on the same target run. The aim should be to allow aircraft to dispense chaff at will for self-defence without affecting following aircraft. This may need to be balanced against a requirement to concentrate aircraft during weapon delivery, especially if the choice of attack tracks is limited.

4.(S) **Ground Jammers.** The possible ground based radar jamming threat to the Tornado is posed by the DOG CART jammer. This mobile jammer has both repeater and noise jamming modes and can automatically track its victim. Only a limited number of jammers are known to have been produced and, therefore, blanket jamming coverage at low level is unlikely. Jammers will probably be used primarily to support major thrusts and to protect high value, first echelon and rear area targets. In such circumstances it is assessed that DOG CART would be used to generate false targets for ground mapping radars. To be successful the jammer requires high aerial gain and accurate tracking; DOG CART is probably not ideal for this purpose. An assessment of the effects of the DOG CART jammer was carried out by CTTO during Trial LEINSTER and the results are summarised at Section 2, Chapter 1, paragraph 3.

5.(S) **GMR and Jamming.** The GMR demonstrated impressive performance against high powered radar jammers during Trial ERUPT. In the fixed frequency mode, the GMR is likely to be affected by even a moderate powered noise jammer but the effects can be clearly seen. The frequency agility mode of the GMR should be used once jamming is seen on the radar display. The pulse compression feature of the GMR is another important ECCM facility which does not affect radar resolution. The selection of off-boresight offsets would assist in negating the effects of a jammer located on the target. Against repeater jammers, which generate the display of false targets, accurate monitoring of the navigation system coupled with the use of offsets should help to indicate the correct target. Trial LEINSTER also addressed the effects of DOG CART jamming on the GMR.

6.(S) **TFR and Jamming.** Unlike the GMR, the TFR does not have a random frequency agile mode; the radar merely cycles over a series of pre-set frequencies. It is, therefore, most important to deny the enemy knowledge of those frequencies by delaying the selection of frequency agility until jamming is seen on the E-scope. Trial ERUPT demonstrated the susceptibility of the TFR to a jammer of greater power than DOG CART. In most cases the ATF system was unable to maintain the aircraft in low level flight, even with frequency agility selected, unlike the effect produced by DOG CART during LEINSTER. A small turn of about 10° to either side of the jammer may reduce the effect of the jamming, (the RHWR may indicate the bearing of the jammer), although if there is no indication of the jammer's direction the turn could exacerbate its effect. If a turn is not possible or if turns each way give no improvement, the crew could deselect automatic TF and manually fly the aircraft using the E-scope. It should be possible to maintain level flight in a jamming environment, although some increase in height would be inevitable. The wartime use of RHH should be considered during planning and suitable areas marked on the map for easy reference. ECCM features introduced with the EV3 standard nose radar (Mod 11133) should help to overcome some of these limitations.

7.(S) **Chaff Against GMR.** The GMR is susceptible to chaff used to hide both offsets and targets. Obscure offsets are less likely to be protected by chaff, but those close to the target may be coincidentally obscured. Similarly, offsets away from the immediate target area should remain visible. In VMC, all-sensor offsets should overcome the problems caused by chaff, while off-track offsets should negate the effects of target area chaff.

8.(S) **Chaff Against TFR.** The deliberate use of chaff by an enemy to cause pull-up commands in TFR systems is unlikely as it would also cause degradations in the performance of their own fire control radars. During a FEBA-type penetration, other chaff, perhaps sown by ground forces, could affect Tornado aircraft over a broad front. Such chaff is less likely to be present on the flanks of major thrusts where Tornado crews should plan their FEBA penetration; however, its effects cannot be discounted. The Heading Hold mode should be used to fly 'around' the chaff. If this is not possible, crews will need to use E-scope TF or RHH to maintain low level. The frequency agility mode of the TFR may be used but is likely to be of little effect. The TFR should be returned to fixed frequency to deny the enemy any intelligence. Once the aircraft has been engaged by enemy air defences, the element of surprise is generally lost. The GMR could, therefore, be used to determine the presence of chaff and to select routing to avoid the major concentrations.

> **Note: Neither E-scope TF nor RHH overland are permitted by the Release to Service and should not be attempted in peacetime.**

RT INTERFERENCE

9.(U) Modern radio jammers take less than one second to cue to and jam a particular frequency. Noise jamming will be, at best, a nuisance and could be almost painful. Spoofing, the transmission of misleading information such as the re-transmission of formation members calls, could cause crews to react unnecessarily. To prevent either of these effects, the radio must be reserved for the transmission of essential action calls only, eg 'Break', followed, if possible, by the callsign. In this way, at least the action itself should be transmitted and crews not affected can react if they are in any doubt. Therefore, routine radio calls must be avoided. Frequency changes should be initiated at a geographic point, or on time prompted by a single word codeword.

10.(R) **Codewords**. The use of codewords should be strictly limited as the in-flight translation of daily changing codewords can be time consuming and confusing. Voice authentication is the easiest means of ensuring that an RT message is genuine, although spoofing by means of re-broadcasting recorded messages is possible. The 'chop' or 'chattermark' can be called by any formation member but, as peacetime flying ably demonstrates, there is no guarantee that messages transmitted from one aircraft will be received by another.

11.(R) **Anti-Jam Radio**. For Operation GRANBY, an AN/ARC 164 RT 1505 UHF transceiver, which was compatible with both HAVE QUICK I and II, was fitted in the front cockpit. The radio provides a frequency-hopping capability, in addition to normal operation, and gave the Tornado a much needed anti-jam radio capability which overcame most of the problems highlighted in the above paragraphs, although in a busy RT environment HAVE QUICK can be noisy. However, until all the Tornado fleet is fitted with an anti-jam radio, squadrons should devise standard procedures to ensure that attack sorties can be successful without the use of the radio.

INTENTIONALLY BLANK

CHAPTER 5 - EMISSION CONTROL (EMCON)

1.(S) The shortcomings and remedies of the Tornado electronic systems are given in the preceding chapters; the CTTO recommend that Tornado crews adopt the following EMCON procedures:

GMR	M + R and INT FIXED FREQUENCY - until jamming is experienced LONG PULSE OFFSETS - off-boresight and all sensor whenever possible The GMR should be used for the minimum time required using the NHC intermittent trigger. Different fixpoints should be used for the left and right hand sides of a formation
TFR	STANDBY - until required FIXED FREQUENCY - normally FREQUENCY AGILITY - when jamming is experienced
RHH	Wartime only
Doppler	ON
Rad Alt	ON (Low Band)
RT	Minimum RT Automatic frequency changes No check-in Action call first
SKY SHADOW	STBY - both bands just before take off ON - both bands at FEBA or in area of high work load. STBY.- both bands on exiting areas ON - both bands at radar lock. STBY - radar lock definitely broken INHIBIT - as required

INTENTIONALLY BLANK

CHAPTER 6 - LASER SENSOR DAMAGE WEAPONS (LSDW)

INTRODUCTION

1.(C) In recent years the Soviets displayed a level of laser technology which indicated that they were capable of achieving a 'soft kill' against electro-optical systems. The extent to which they have exploited this capability is uncertain, but it is believed that LSDW are already mounted on some of the ex-Soviet Navy's cruisers. The human eye is vulnerable to even modest laser beam energy levels, and the potential to 'add-on' small, relatively low-powered, LSDW equipment to existing SAM and AAA systems must also be considered in any discussion of a potential enemy's offensive laser capabilities.

2.(R) LSDW are becoming an increasingly important electronic warfare weapon which could pose a lethal threat to aircrews carrying out visual low-level attacks. This Chapter explains how lasers achieve sensor damage, postulates an LSDW threat, discusses the implications for our current low-level tactics and lists a number of methods of countering the threat posed by LSDW.

SENSOR DAMAGE

3.(S) The eye is sensitive to light radiating at wavelengths from 0.35μm to 0.8μm in the visible spectrum. Ultra-violet radiation occupies the band 0.35μm to 0.003μm and infra-red from 0.8 to 1000μm. Existing lasers operate in all three of these bands and thus cover not only the wavelengths of the human eye but also those of Image Intensifiers (II) and Thermal Imagers (TI) as shown in Figure 4-6-1.

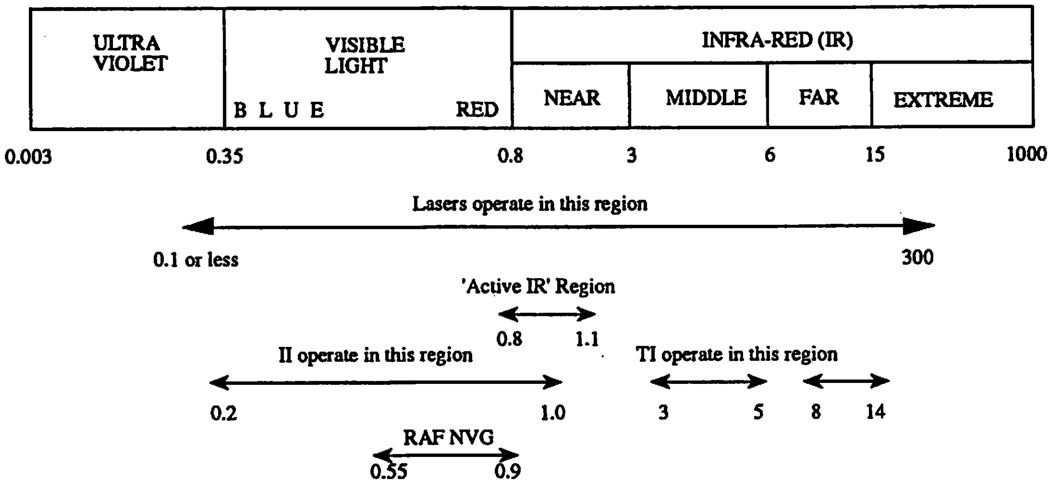
4.(R) A number of factors determine the extent of damage to targets such as the eyes, ordinary glass optics, or the electro-optics of thermal imagers and image intensifiers. These are:

a. The nature of the target.

b. The energy density directed at the target.

c. The frequency and power level of the laser.

d. The atmospheric attenuation between the laser and the target.



All wavelength data is given in "microns" (μm) - 1m x 10^{-6}

Figure 4-6-1(R) - Laser Wavelengths

5.(R) **Laser Damage**. The types of damage caused by lasers are as follows:

a. **Dazzle**. Dazzle is usually associated with very low energy lasers and implies temporary dazzling such that nothing else can be seen in a particular direction. The laser has to be working at the same wavelength as the sensor (eye, II or TI), and has to deposit sufficient energy to saturate the detector.

b. **In-Band Damage**. In-band damage is a form of permanent damage usually caused by low or moderate energy lasers. The radiation is of such a wavelength that it will pass through the eye or optical lens and deposit sufficient energy to destroy the detector behind the lens.

c. **Out-of-Band Damage**. Out-of-band damage is normally associated with moderate or high energy lasers and is sometimes known as 'soft-kill'. The laser has a wavelength which will not pass through the lens or aircraft canopy and therefore deposits its energy on the lens or plexiglass; the result is crazing, frosting or shattering. (See note below).

d. **Structural or Catastrophic Damage**. Extreme forms of structural or catastrophic damage are caused by high energy lasers and are sometimes known as 'hard kill'. The laser's wavelength is almost irrelevant as sufficient energy is deposited onto the target to shatter lenses, cause fires or burn holes in the structure.

Note: When referring to lasers, the term 'eye safe' can be misleading. For example a CO_2 laser does not endanger the light sensitive parts of the eye. However, a CO_2 laser of sufficient power could deposit enough energy on the eye lens to cause it to become opaque or even to burst. Carbon dioxide lasers are not therefore necessarily 'eye safe'.

THE LSDW THREAT

6.(S) **Overland Threat**. RAE studies suggest that LSDW deployed overland would be integrated with SAM and AAA field units and would therefore be subject to the same command and control structure. A LSDW could be mounted on a BRDM-type vehicle and used as an integral air defence weapon, alternatively, the equipment could be used as a laser range finder/LSDW added to systems such as SA-8 to provide the ranging information which the system is denied in anti-jamming reversionary modes, and to attack eyes and EO sensors. Relatively low powered LSDW are capable of generating 'catastrophic' eye damage at ranges of up to 4 km.

7.(S) **Maritime Threat**. Shipborne LSDW are likely to be capable of producing greater beam energy levels than their mobile land-based counterparts because high power electrical supplies are readily available. The relationship between energy level, laser type, and damage levels are given in Annex A.

8.(S) **Damage Effect**. It is impossible to calculate precisely how an LSDW will affect a particular EO device because the extent of damage will depend on the overall received energy, which will vary with range, attenuation, power output and other factors. Furthermore, the consequence of the damage will vary from target to target; for example, damage might be sufficiently serious to degrade the accuracy of TV-guided weapons against a small land target, but might not be sufficient to degrade attacks against large targets such as ships. On the other hand, the threat posed by LSDW to the human eye has been demonstrated as the following report shows:

> 'When the beam struck my eye, I heard a distinct popping sound caused by a laser-induced

> explosion at the back of my eyeball. My vision was obscured almost immediately by streams of blood and what appeared to be particulate matter suspended in the vitreous humour ..... As a Vietnam War Veteran, I have seen terrible scenes of human carnage, but non affected me more than viewing the world through my blood-filled eyeball. In the aftermath of the accident I went into shock .....'

The report is that of a Laboratory Technician who experienced the effect of a close-range, low-power laser on his eye. In 1981, an American police helicopter crew were temporarily blinded by a low power laser while night flying. The effects were restricted to flash blindness and disorientation, and the pilot was able to land safely nearby. Both these incidents could have had disastrous consequences if the victims had been aircrew operating at low altitude and high speed.

TACTICAL IMPLICATIONS

9.(S) **Acquisition.** The initial tracking of an aircraft and aiming of a LSDW can be carried out using radar, but ultimately the target would have to be tracked optically. The tracking accuracy to achieve a given laser hit probability is determined by the divergence of the laser beam and the size of the vulnerable area of the target. In the case of sensors such as the human eye or a vidicon TV camera the vulnerable area is small, and the laser beam would need to be placed precisely over a specific part of the aircraft. Thus, as with any system which depends on accurate line-of-sight engagements, LSDW may be defeated by tactics such as terrain screening and manoeuvre which make acquisition and tracking more difficult.

10.(S) **Crew Vulnerability.** Most of our present day weapon delivery profiles require a close approach to the target and depend predominantly on visual acquisition by the pilot. Under these attack conditions the pilot's attention is almost wholly directed towards the target area and the eyeball is therefore particularly vulnerable in terms of 'look probability'. At short ranges the eye could be damaged by an LSDW of around 2 joules beam energy; the Soviets are known to have laser range finders capable of this order of output in service now. It follows that adequate protection is unlikely to be achieved by tactics alone and our freedom to operate at low level will be curtailed unless an added safeguard for aircrew eyesight can be found. Without this additional protection the shock of a laser hit on the eye would probably cause the crew either to climb into a conventional air defence threat zone or to crash.

COUNTERS TO LSDW

11.(C) **Active Protection.** The narrow beam of the LSDW requires an extremely accurate tracking system; either optical, or radar and optical. An active ECM pod or chaff could counter the LSDW radar tracker, and IR flares could be dispensed in order to confuse a thermal imaging or optical tracker. However, without some form of warning of the presence of a LSDW system, a high degree of risk to aircrew eyesight will remain.

12.(S) **Passive Protection.** A number of passive equipments and techniques either exist or could be developed to reduce the LSDW threat to an acceptable level; these include:

a. **Eye Patch.** Medical opinion differs as to the degree of protection provided by the eye patch when the other eye is physically injured. It has been argued that the brain would cut off vision from the unaffected eye for some time as a result of the trauma caused by the laser-induced explosion in the affected eye, thus effectively rendering the crew blind for a finite period after exposure.

b. **Internal Reflections.** Around 20% of light energy is absorbed by an aircraft canopy. Eighty percent of any laser energy would remain for direct transmission or reflection into the eyes of the crew from internal reflective surfaces such as the canopy itself or the instruments. In level flight the canopy would be the main source of reflection, whereas during steep turns many other reflective surfaces could become laser mirrors. The number of reflective surfaces can be reduced by ensuring that, wherever possible, cockpit surfaces are rough-textured and matt black, and that glass instrument faces are angled away from the line of sight.

c. **Aircrew Visor.** The aircrew visor reduces laser transmissivity and thus reduces LSDW effective range; if absorbing plastic filters are incorporated in the visor they could filter out some laser wavelengths completely. However, the commercially available filter which provides eye safety at all ranges against Ruby and Neodymium lasers, for example, has a visual transmissivity of only 25%. Essentially, visor protection is possible against an identified fixed-frequency LSDW, but a visor which filters more than one laser frequency is unlikely to be acceptable for visual operations because of the significant reduction in light transmissivity. See also paras 13 and 14 below.

d. **Laser Warning Receiver (LWR).** It is possible that a laser beam illuminating an aircraft canopy by day would go unnoticed by the crew until the beam was accidentally looked at. By night, the beam should cause a bright flash in the canopy and thus alert the crew - although the natural and potentially hazardous reaction would probably be to look at the spot on the canopy. A LWR would alert the crew to the azimuth position of the LSDW and enable suitable action to be taken. At present the only recommended actions are to look down, if possible, until the threat passes and to initiate the dispensing of chaff and flares, and perhaps commence active jamming. Preliminary studies are underway into the feasibility of providing aircraft with a LWR.

e. **Flash Visor.** The ideal protective visor would be almost transparent until activated by a hazardous laser source, when it would instantaneously become nearly opaque. However, existing materials, designed to protect against nuclear flash, react too slowly to counter laser pulses. It may be possible, in the future, to develop a visor which would counter both nuclear flash and LSDW, and such a visor would ideally be provided together with a LWR.

f. **Reflective Spectacles.** A recently developed technique of coating plain glass has made it possible to manufacture aircrew spectacles which are capable of reflecting the three most significant laser frequencies. These spectacles are comfortable and could be worn under the AR-5 respirator. Although the spectacles may have a visual transmissivity of only 50% and will not be able to counter the tuneable lasers which may be expected later this decade, they will offer some form of protection in the short term.

g. **Night Vision Goggles (NVGs).** Because there is no direct optical path to the eye through NVGs, they could provide effective protection against LSDW by night or day, if fitted with a light-tight eyepiece shroud.

Alternatively, to enable the pilot to view the cockpit from beneath 'look around' NVGs while retaining laser protection, cockpit transparencies would have to be suitably filtered and the pilot equipped with a tinted face mask. It is estimated that a medium-powered laser hit would not completely blacken the view through the NVG but would create a black pinhole on the inner coating of the viewing lens. When used in conjunction with a LWR, the cause of any degradation in performance of the NVG should therefore be immediately apparent.

PILKINGTON OPTRONIC PROTECTION VISOR

13.(SUKB) **Anti Laser Eye Shield (ALES 1).** An anti-laser eye shield has been produced for in-service use by Pilkington Optronics. Directed energy weapons (DEW) is a very sensitive subject and the **following information is released on a need to know basis.** DEW have been in the research phase since early 1980s and ALES 1 is part of an EOCCM programme to provide protection. Many previous devices have failed after initially showing promise and it is important that only fully authorised equipments are used. A balance has to be achieved between protection and performance, in particular the need to retain adequate pilot visibility. Earlier visors performed well at designated frequencies but did not allow HUD symbology or TV tab symbology to be seen. The lastest ALES 1 do not suffer from these earlier problems. Development models are made of polycarbonate into which several dyes have been mixed and the visors are then moulded into shape. Minor imperfections include small black dots of concentrated dye but these do not affect protection qualities. Light surface scratches will not affect protection at lasing frequencies. The visors have passed normal impact testing. Visors have been checked for compatibility with individual aircraft - and cleared for use in Tornado. ALES 1 is designed to protect against three main lasing wavelengths: 0.53µm (ND-YAG doubled), 0.69µm (Ruby) and 1.06µm (ND-YAG). These are common battlefield laser rangefinder frequencies.

14.(SUKB) **Use of ALES 1.** The visor gives everything within its field of view (FOV) a yellow-orange tinge, but does not appear to reduce the light level any more than a normal dark visor would under similar conditions. It is an effective sun visor. However, when flying over brownish-yellow terrain, with bright-hazy conditions the yellow 'tinge' produces an effect which **might** slightly reduce the visibility. There are no problems viewing any cockpit displays in the NVG or non-NVG cockpits, although as with the normal dark visor, controls and indicators in the darker areas of the cockpit are not easy to see. The major factor to consider when wearing the visor is the 'visual illusions' effects of hiding the small 'Wadi' in the foreground, particularly at low sun angles. The CTTO recommendation is to use the visor at all times when transitting at high level (as a sun visor) and at all times when in the threat area (as a laser visor). When transitting at low level in friendly territory it is advisable to fly with the visor up (flight safety) provided the sunlight conditions will permit.

CONCLUSION

15.(S) No one tactic or single item of aircrew protection will completely remove the threat from LSDW. It is likely that a number of complementary devices and tactics, which will almost certainly impose restrictions on visual operations, will be needed to counter the threat effectively. It follows that the operational flexibility afforded by visual low level attacks can no longer be taken for granted, particularly in those areas where LSDW can be expected such as on or near a FEBA and around high value, fixed installations or maritime targets. However, countermeasures to the LSDW threat are being investigated and developed as a matter of urgency.

ANNEX A TO
SECTION 4, CHAPTER 6 OF
TORNADO GR1 TACTICS MANUAL

RELATIONSHIP BETWEEN OUTPUT POWER, LASER TYPE AND DAMAGE LEVELS

		DAMAGE CAUSED TO TARGET		
OUTPUT POWER	LASER TYPE	UNPROTECTED EYE	II DEVICE	TI DEVICE
VERY LOW ENERGY LASERS 1W	Ruby 0.69µm	In band - Temp. Dazzle	In band Temp.Dazzle	Out of band No effect
	Frequency Doubled Nd/Glass 0.53µm	In band - Temp. Dazzle	In band Temp.Dazzle	Out of band No effect
	CO_2 10.6µm	Out of band No effect	Out of band No effect	In band Temp.Dazzle
LOW ENERGY LASERS 1-1000W	Ruby 0.69µm	In band - Perm. Blinding	In band Perm.damage	Out of band No effect
	Frequency Doubled Nd/Glass 0.53µm	In band - Perm. Blinding	In band Perm.damage	Out of band No effect
	Argon Ion Various Wavelengths Blue/green (0.48 - 0.53µm)	In band - Perm. Blinding	In band Perm.damage	Out of band No effect
	CO_2 10.6µm	Out of band Damage depends on energy density	Out of band No effect	In band Minor permanent damage
MODERATE ENERGY LASERS 1kW-500kW	Nd/Glass 1.06µm	In band Permanent Blinding and Physical Damage	In band Permanent Damage	Out of band Minor Permanent damage to lenses
	CO_2 10.6µm	Out of band Permanent Blinding Physical Damage	Out of band Permanent Damage & Minor Structural Damage	In band Destroys Detector Array
HIGH LASER LEVEL >0.5MW	CO_2 10.6µm	Out of band Permanent Blinding and Physical Damage	Out of band Structural Damage	In band Structural Damage

Note: 1 watt = 1 joule/sec

INTENTIONALLY BLANK

Section 5

Mission Planning

Chapter 1 **War Procedures**

2 **Weapon-to-Target Matching**

3 **Aircraft Performance**

4 **Mission Planning Facilities and Procedures**

5 **Target Area Planning**

6 **Route Planning**

7 **Attack Mission Briefing Guide**

8 **AAR**

SECTION 5 - TABLE OF CONTENTS

CHAPTER 1 - WAR PROCEDURES

Page number (within the Chapter)

INTRODUCTION 1

TASKING METHODS 1
- ATO. 1
- ATM. 1

TORNADO MISSIONS 1
- OCA. 1
  - Initial Offensive Counter Air (IOCA). 1
  - Follow-on OCA Mission Tasking. 2
- AI. 2
- OAS 2
- BAI. 2

TASKING PRIORITIES 2

AIRCRAFT TARGETING 2
- Area Reference System (ARS). 2
- Target Identification. 3

MISSION NUMBERING SYSTEM 3
  - Type of Mission. 3
  - Request/Tasking Agency. 3

CONVENTIONAL LOADS (CL) 3
- CL Numbering System 3

AIRSPACE MANAGEMENT 4
- SUPPLAN MIKE 4
  - Central Region 4
  - Denmark/Norway 4
  - UK Airspace 4
- Airspace Co-ordination Order (ACO). 4
- IFF. 4

ELECTRONIC WARFARE (EW) 5
- EW Resources. 5
  - Wild Weasel (WW) Aircraft. 5
  - ALARM Aircraft. 5
  - Jamming (ECM) Aircraft. 5
  - Army Assets 5
  - Chaff 5
- EW Operations 5
  - WW 5
  - Raven 5
  - Compass Call 6

FIGHTER SUPPORT 6

AEW SUPPORT 6

AAR 6

INTELLIGENCE 6

MISSION REPORTS 6
In-Flight Reports (IFREPS). 6
Mission Report (MISREP). 6

ANNEXES

A: - Air Request Task Message - Proforma A1
B: - Typical OAS ARS and OCA Targeting Area B1
C: - In-Flight Reports (IFREPS) C1
Airspace Management Definitions C1
Air Route (AR) C1
Amphibious Objective Area (AOA) C1
Base Defence Zone (BDZ) C1
Coordination Level C2
Forward Area C2
High Density Airspace Control Zone (HIDACZ) C2
Hostile Aircraft Free Engagement Zone (HAFEZ) C2
Low Level Transit Route (LLTR) C2
Maritime Air Coordination Area (MACA) C2
Minimum Risk Levels C2
Rear Area C2
Restricted Operations Zone (ROZ) C2
Safe Lanes C2
Special Corridors C2
Transit Corridor (TC) C2
Temporary Minimum Risk Route (TMRR) C2
Weapons Free Zone (WFZ) C2
D: - SEAD Box Definitions D1

CHAPTER 2 - WEAPON TO TARGET MATCHING

INTRODUCTION 1

WEAPONS 1
JP233 1
Effectiveness of SMs 1
Target Thickness 2
Structure of Sub-Soil 2
Stick Length 2
Release Height 3
Wind Effect 3

1000LB HE (MC) BOMB 3
Tails 3
Penetration Cabability 3
Impact Data 4
Weapons Effects with MFBF 5
Delivery from Medium Altitude 6

PAVEWAY LGB 6

BL755 6

MAUSER CANNON 6

ALARM 6

NATO WEAPONS 6

OCA TARGETS 7

AIRFIELD TARGETS 7
  AOS 7
    JP 233 7
    1,000lb Bomb 8
    LGB 8
    BL 755 8
  HASs/COCs 9
    1,000lb Bomb 9
      Retard Bomb 9
      FF Bomb 9
    LGB 9
    BL755 10
    27 mm Cannon 10
  Aircraft 10
    1,000lb Bomb 11
    BL755 11
    Mauser 27 mm Cannon 11
  Installations. 11

RADAR TARGETS 11
  DMPIs 11
  Target Characteristics 11
  Choice of Weapons 11

SAM TARGETS 12
  DMPIs 12
  Fixed SAM Sites 12
    SA-2 12
    SA-3 12
    SA-5 12
    SA-10a 12
  Mobile SAMs 13

AI TARGETS 13

MOBILE TARGETS 13
  Bridging Equipment 13
  Choice of Weapons 13

FIXED TARGETS 14
  Permanent Bridging 14
  Railway Yards 15
  Headquarters / Depots 15

BAI TARGETS 15

ARMOUR 15
  1,000 lb Bomb 16
  BL755 16
  27 mm Cannon 16

TROOPS 16

TARGETS OF OPPORTUNITY (TOO) 16

MISSILES/ARTILLERY 16

AAA 17

HELICOPTERS 17

SUMMARY 17

ANNEXES
A: - Weapon-to-Target Matching Guide A1
B: - JP233 Ejection Timing for Cratering Munition (for each dispenser) B1
C: - JP233 - Results from TYNE 4 - Patterns C1
D: - JP233 - Runway Cratering SM Success Rates D1/2
E: - Typical 1,000lb Bomb Stick Patterns E1/3
F: - MFBF Fusing Information F1/2
G: - Minimum Required Take-off Surfaces for Ex-Soviet Type Fighters G1/2
H: - Probability of Cutting Runway with Across Attack H1
I: - Guide to JP233 Targeting of Airfields I1/2

CHAPTER 3 - AIRCRAFT PERFORMANCE

INTRODUCTION 1

PERFORMANCE DATA 1
Use of the ODM 1
Fuel Flows 1
Use of Auto-throttle 1
Engine Thrust 1
Radii of Action 1

PERFORMANCE COMPARISON 1
SEP 1
Turn Rate Analysis 2
Use of Turn Rate Analysis Graphs 2
Tactical Use of Reheat 2

PERFORMANCE AT HIGH AUW 2
Trial TWIBILL 2
Trial NONIYS 3

AAR 4

ANNEXES
A: - Aircraft Performance - Trial NONIYS A1/2
B: - Tornado GR1 Declared Radius of Action B1/2
C: - Tornado and Threat Aircraft Performance C1/13

CHAPTER 4 - MISSION PLANNING FACILITIES AND PROCEDURES

INTRODUCTION 1

PLANNING FACILITIES 1

Information Sources 1
Planning Aids 1

PRE-PLANNED OPTIONS/ ON-CALL TASKING 1

TASK RECEIPT 2

PLANNING CONSIDERATIONS 2
Time Available 2
Night/ All - Weather Missions 2
Other Missions (except CAS) 2
Weapon Load 2
AAR 2
Visual/ Non-Visual Conditions 3
Number of Aircraft 3
Other Information 3
Formations 3
Goose 3
Card 4
Battle Pair 4
SUPPLAN MIKE 5
Target Area Intelligence 5
Target Area and Route Planning 5
NBC 5

CHAPTER 5 - TARGET AREA PLANNING

INTRODUCTION 1

TARGET/OFFSET ACQUISITION 1
Radar Significant Features 1
Terrain Screening/ Aircraft Height 1
OAP Selection 1
Choice of Radar Offsets 1
Choice of Visual OAPs 2
Choice of All-Sensor OAPs 2
Offset Calculations 2
Visual Target Acquisition 2
In-Flight Visibility/ Weather 2
Target Size and Contrast 3
Cockpit Environment 3
Electro-Optical (EO) Sensors 3
Crew Workload 3

DMPI/AIMPOINT 4

ATTACK DIRECTION/LOA 4

ATTACK PROFILES/ DELIVERY TYPES 5
Factors to Consider 5
Accuracy Versus Attrition 5
Weapon Effects 5
Topography 5
Vulnerability to Target Defences 5
Surprise 5
Defence Saturation 5
Speed 6

        Visual/ Non-Visual Conditions 6
        IMC Considerations 6
        Weapon Aiming Accuracy 7
        Choice of Sensor 7
            General 7
            Phase 1 Laydown Attacks 7
            Loft Attacks 8
            Phase 2/3 Attacks 8

WEAPON AIMING PROCEDURES 9
    JP233 - General 9
    JP233 - Software 9
        Centre Stick Aiming 9
        Along' Attacks 9
            Selection of Fixed Attack 9
            Time/ Range to Target 10
            HSI Demanded Track 10
            Track Capture 10
        Across' Attacks 10
    JP233 - Planning Sequence 11
    JP233 - Execution 12
    Level Retard Attacks 12
        Attacks in Non-Visual Conditions 12
        Attacks in Visual Conditions 12
    Shallow Dive Retard Attacks 13
        Attacks in Non-Visual Conditions 13
        Attacks in Visual Conditions 13
    Low Loft Attacks 13
        Attacks in Non-Visual Conditions 13
        Attacks in Visual Conditions 13
        Loft Recoveries 14
    Mini-Loft Attacks 14

REVERSIONARY WEAPON AIMING 14

INTEGRATED FORMATION ATTACK PLAN 14
    Transition from Route Plan to Attack Plan 14
    Final Height Fix 14
    ASD Risk 14
    Deconfliction of Tracks 15
        Minimum Separation over Target 15
        Attack Plan/Escape Plan 15
        Alternative TOTs 15
    Close Formation Attacks 17
        JP 233 17
        Free-Fall Bombs 17
        Retard Bombs 17
        BL 755 17
        Cannon 17
    Attacks in Trail 17
    Attacks against Separate DMPIs 17

OPERATIONAL DEGRADATION 18
        Software Improvements 18
        Training Scores 18

SUMMARY 18

ANNEXES

A: - Tornado Offset Calculations A1
B: - Deficiencies in Cockpit Ergonomics - Trial Rubian B1
C: - JP 233 - 60° Capture Template C1
D: - JP 233 - Tracking Errors D1
E: - Four Methods of Removing Wind Effect in Loft E1

CHAPTER 6 - ROUTE PLANNING

INTRODUCTION 1

NON-VISUAL PLANNING 1
- Choice of Formation 1
- SUPPLAN MIKE 1
- Recovery Procedures 1
- Route Selection 1
- Fixpoint Selection 2
- Height Fixing 2
- Timing 3
  - Datum 3
  - Turns 3
  - Leg Speed 3
  - Leg Length 3
  - Timing Reference Points 4
  - Use of CPGS 4
  - Alternate TOTs 4
  - Parallel Tracks 4
- Fuel Planning 5
- Losers 5
- Route Study 5
- Reversionary Modes/ Calculation of Safety Heights 5
  - GMR Terrain Avoidance (TA) Mode 5
  - Safety Heights 5

VISUAL PLANNING 6
- Choice of Formation 6
- Route Selection 6
- Fixpoint Selection 6
- Height Fixing 6
- Timing 7

CONCLUSION 7

CHAPTER 7 - ATTACK MISSION BRIEFING GUIDE

INTRODUCTION 1

ATTACK PLANNING SEQUENCE 1

ATTACK PLANNING GUIDE 1

ATTACK MISSION BRIEFING GUIDE 1

ANNEXES

A: - Attack Planning Sequence A1
B: - Attack Planning Guide B1
C: - Attack Mission Briefing Guide C1/4

CHAPTER 8 - AIR-TO-AIR REFUELLING

GENERAL PROCEDURES 1
- Tactical AAR 1
- RV Procedures 1
- GMR Procedure 1

OPERATIONAL EMERGENCY AAR 1

INTRODUCTION 1

USAF GENERAL PROCEDURES (CONUS) 2
- Refuelling Order 2
- Radio Procedures 3
- Visual Signals 3

KC135/KC135R TANKER 4
- Observation Position 6
- Line Up Procedure 6
- Approach to Contact 6
- In Contact 6
- Disconnects 6

KC10 TANKER 6
- AAR Equipment 6
- Observation Position 7
- Lighting 8
- Contact Technique 9
- KC10 Hose Drum Unit Light Signals 10

ANNEXES

A: - BUCCANEER - TORNADO AAR PROCEDURES A1/4

CHAPTER 1 - WAR PROCEDURES

INTRODUCTION

1.(U) This Chapter of the Manual cannot provide a complete guide to all war procedures; the intention is to give an outline of some major topics and to provide references for greater in-depth study should it be required. The Section addresses NATO tasking procedures only, of which many are included in the scenarios of FLAG exercises. Although the NATO procedures need revising in view of magnitude of the changes which have taken place in Europe since 1989, the general principles are still valid. Furthermore, many of these procedures are applicable to OOA operations and were practised with good effect during Operation GRANBY.

TASKING METHODS

2.(R) Within ACE, subordinate commands have differing organizations to allocate tasks. For example, the tasking of 2 ATAF attack units will normally be effected by the ATOCs as directed in the 2 ATAF Daily Operations Order (DOO). Full procedures will be found in AAFCE Manuals 80-2/3 and COMTWOATAF SUPPLAN 32001B. Tasking is in three forms:

a. Air Task Order (ATO).

b. Air Task Message (ATM).

c. Implementation of Prepared/ Preplanned Programmes.

3.(R) **ATO.** Following receipt of a DOO, ATOCs will issue an ATO to Wings, Corps and ASOCs by 2300Z for the following 24 hour period commencing 0300Z. This is a comprehensive order giving not only instructions for specific targets but also covering EW and fighter support, AAR and even how the effort is to be spread across the day.

4.(R) **ATM.** ATMs conform with ATP 27(B) and most are of standard format for computer processing (eg AAFCE Form 8001). Although there are minor variations between nations and NATO commands, all are similar to the example at Annex A. Some nations refer to ATMs colloquially as FRAGs (Fragmentary Orders). Other specific messages are used to task SEAD, EW, AD or Air Reconnaissance. Normally there is sufficient target information in the ATM alone, but if not, then clarification can be sought from the ATO. ATMs may be transmitted by telephone, teletype or ADP systems.

TORNADO MISSIONS

5.(C) (References AAFCE Manuals 80-2/3 and COMTWOATAF SUPPLAN 32001B). The most likely missions for Tornados are:

a. Offensive Counter Air (OCA).

b. Air Interdiction (AI).

c. Offensive Air Support (OAS) - most likely to be restricted to Battlefield Air Interdiction (BAI)

6.(S) **OCA.** Counter Air operations are conducted offensively and defensively to achieve a favourable air situation and to minimise enemy air interference with the effective operation of friendly forces. OCA operations are those mounted to destroy, disrupt or limit enemy air power as close to its source as possible. OCA operations are carried out in two phases as follows:

a. **Initial Offensive Counter Air (IOCA).** The aim of IOCA is the maximum disruption of enemy air operations which pose the biggest threat, ie long-range SAM sites, aircraft MOB and C^3 systems; in most cases these will be pre-planned. IOCA missions, which are likely to employ all available EW assets, will most probably require AD support.

b. **Follow-on OCA Mission Tasking.** After IOCA missions have been executed, squadrons will stand-by for on-call tasking, with follow-on OCA missions the most likely task. Missions will be allocated in the manner described in Para 2.

7.(S) **AI.** AI missions are conducted to destroy, isolate, neutralise or delay the enemy's military potential before it can be brought to bear effectively against friendly forces. AI missions are carried out at such a distance from friendly forces that detailed integration of each mission, with fire and movement of friendly forces, is not required. AI missions will primarily be executed against mobile and fixed targets beyond the RIPL, typically more than 80-100 km beyond the FLOT. Although the majority of AI targets will be selected after reconnaissance has detected force concentrations, there could be a pre-planned AI programme.

8.(S) **OAS.** OAS tasks, of which BAI is one, are designed to permit timely, flexible responses to any enemy incursions; ranging from an attack with minimum warning and no reinforcement, to a full-scale assault after a period of tension and build-up. Contingency plans could include pre-planned options which have been prepared for quick reaction in the early stages of any conflict. Although it is unlikely, Tornados could be allocated to the following tasks in an emergency.

a. Artillery concentrations.

b. Assembly areas of follow-on forces.

c. Choke points.

d. Vital fixed installations, particularly C^2 facilities.

In addition, Army Corps may have identified target areas, associated with covering force killing zones, into which enemy forces will be channelled and into which OAS missions will be tasked to destroy validated enemy formations. As the zones are related to army battle plans, some prior mission preparation can be done and GLOs should have briefing material and maps of the likely target areas available.

9.(C) **BAI.** BAI is air interdiction against hostile surface targets which are in a position to affect friendly forces directly; but they are air missions that do not require detailed integration with the fire and movement of those forces. These air missions can have a direct affect on the enemy's ability to continue operations and may be conducted either side of the FSCL. While BAI missions require co-ordination in joint planning, they may not require continuous co-ordination during the execution stage. However, BAI missions executed against targets short of the FSCL, must be co-ordinated by/with the appropriate Corps.

TASKING PRIORITIES

10.(S) (Reference AAFCE Manual 80-3). SNOWCAT is the employment of conventional air assets to improve the probability of success for strike missions and it forms the primary conventional task for Tornado wings. However, above that, maintenance of the declared FGL and any "Selective Use" tasks have priority. Other missions that have been tasked in the normal manner should be flown according to the priority given in the ATM.

AIRCRAFT TARGETING

11(S) **Area Reference System (ARS).** (Reference AAFCEE Manual 80-3) An ARS has been developed as an aircraft targeting aid. The system aligns aircraft radii of action with specific operating areas to provide a quick reference method for aircraft/ weapon-to-target matching. A typical OAS ARS and OCA targeting area is at Annex B.

12.(C) **Target Identification.**; There are several ways to identify a target. The most accurate is generally required and some methods are listed below:

a. Basic Encyclopaedia (BE) Number.

b. 2 ATAF Conventional Target List.

c. Linesearch System.

d. UTM or GEOREF.

e. Latitude and longitude.

f. Allied Targeting Data Base (ATDB).

g. Information from AOB, EOB or MOB catalogues.

MISSION NUMBERING SYSTEM

13.(R) (Reference AAFCE Manual 80-3). The NATO standard mission indicator consists of a number indicating the type of mission, one or two letters signifying the Request/Tasking Agency and finally three numbers indicating the mission number, eg 1TM001. The decode for the type of mission and the Request/Tasking Agency is as follows:

a. **Type of Mission.**;

0	VD/PL
1	AI
2	TACR
3	CAS
4	OCA
5	EW
6	TACR(MAR)
7	Air Defence Support
8	Anti-Surface
9	Airborne Radio Relay (Autocat/Middleman)
10	Armed Recce
11	TAC T
12	BAI

b. **Request/Tasking Agency.**;

A	AAFCE
T or Z	2 ATAF
F or O	4 ATAF
B	BALTAP
TK	ATOC KALKAR
TM	ATOC MAASTRICHT
Q	1(NL) Corps
K	1(GE) Corps
M	1(BR) Corps
R	1(BE) Corps

CONVENTIONAL LOADS (CL)

14.(C) **CL Numbering System.**; (Reference AAFCE Manual 80-3). The CL numbering system is based on an eight-digit code; the first indicates nation, the second two aircraft type, the next four configuration and the last any requirements, eg CCC 6752 Q. The terms Preferred Conventional Loads (PCL) or Standard Conventional Loads (SCL) are often used for the conventional load most often employed on a given type of mission. Part of the decode system is shown on the next page.

Nation	Type		CL
B-Denmark	AA-F111A/E	0400-0499	Specialized Anti-Runway
C-UK	CC-Tornado	0500-0599	Specialized Anti-Shipping
E-FRG(AF)	DG-F4D	3000-3999	Rockets
J-US(AF)	GG-Jaguar	4000-5999	Low Drag Bombs
K-US(N)	HH-Harrier	6000-6999	Retarded Bombs
L-US(Mar)	HJ-Sea Harrier	7000-7999	CBU
N-Canada	II-A10	8000-8999	LGB
		9000-9999	Specialized Def Sup

Additional Requirements.

E - RWR + ECM
H - RWR + SPC (self protect chaff and/or flares) + ECM
Q - AIM + RWR + SPC + ECM

AIRSPACE MANAGEMENT

15.(C) **SUPPLAN MIKE.** All air operations within the Northern and Central Regions will be planned and executed in accordance with minimum risk procedures detailed in Airspace Control Plans (SUPPLAN MIKE). A simple diagram of typical SUPPLAN MIKE management areas and definitions are at Annex C. For the UK area of interest in Europe, the plans are held in the following documents :

a. Central Region - COMAAFCE SUPPLAN 35001M

b. Denmark/Norway - CINCNORTH SUPPLAN 20001M

c. UK Airspace - CINCUKAIR SUPPLAN 50001M

Although the validity of many of the geographic co-ordinates and locations the above documents are now in question, the principles and procedures are still valid.

16.(R) **Airspace Co-ordination Order (ACO).** Activation of the various SUPPLAN MIKE areas and routes are detailed in ACOs. In preparation for a future conflict where reaction time may be short, ATAFs will prepare and distribute a "Standing ACO". This will remain active until the ATAF has issued a new ACO that will have one of the validity periods shown below. The new ACO will be aligned to the next regular cycle that allows sufficient distribution time prior to its validity period. The periods are as follows:

ACO 12	0300 - 1059Z
ACO 12A	1100 - 1859Z
ACO 12B	1900 - 0259Z

(Where the number is the day of the month)

17.(S) **IFF.** IFF procedures vary between regions and details are covered in the various Supplans. Current IFF equipment has limitations, the more significant of which are as follows:

a. Susceptibility to jamming, deception and exploitation.

b. Degraded performance due to over-interrogation.

c. Aircraft operating in close proximity to each other may cause mutual interference at the interrogating unit with a resulting risk of mis-identification. However, the mis-identification risk is lower than the risk of a friendly aircraft being engaged when not transponding. Therefore, it is recommended that all aircraft within a formation should transpond the current code unless otherwise directed by a controlling agency.

d. Reliability and maintainability shortcomings.

e. Inadequate all-round IFF signal coverage.

f. Incompatibility between some interrogators and transponders.

In spite of these shortcomings, aircrew are to adopt the IFF procedures laid down even when other minimum risk procedures are being followed. Indeed, IFF provides such a vital part of the minimum risk plans that, should the transponder be unserviceable before take-off, consideration should be given to aborting the sortie.

ELECTRONIC WARFARE (EW)

18.(S) **EW Resources.** (References COMAAFCE SUPPLANSs 35001 and 35001M, COMTWOATAF SUPPLAN 32001F, AAFCE Manual 80-3 and COMAAFCE COMAO SOP). EW resources that may be available are as follows:

a. **Wild Weasel (WW) Aircraft.** The primary role of WW aircraft (currently F4s and F16s predominantly using HARM), is to suppress or destroy enemy air defence weapon systems (SEAD).

b. **ALARM Aircraft.** ALARM will only be carried by RAF Tornado aircraft with the primary role of SEAD either on the way to the target or in the target area.

c. **Jamming (ECM) Aircraft.** Three basic types of ECM aircraft are available. EF-111s (Raven) jam certain radar or non-communication frequencies while EC-130Hs (Compass Call) have a capability against communications, IFF and navigation equipment frequencies. The Canberra T17A has a communications jamming capability.

d. **Army Assets.** Army assets which have a SEAD or C^3 capability may be available for use in co-ordinated Joint Operations.

d. **Chaff.** Chaff support will be conducted in accordance with ATP44.

EW should be considered by commanders at all levels as a weapon to be integrated, with other weapons, in the land/air battle. Although each EW asset is specialized for a particular function, it has greater potential when employed in a concentrated, co-ordinated effort.

19.(S) **EW Operations.** Any IOCA operations would be given the highest priority for the allocation of EW assets. Even so, because of the limited number of assets, only those LLTRs with the most traffic are likely to receive EW support in the corridor suppression role. Therefore, attack assets should make every effort to utilise LLTRs designated in the SOO and ATOs. For on-call tasking operations, EW support should always be requested even though limited resources may prevent its allocation. The concept of operations of EW aircraft are as follows:

a. **WW.** The WW force will be used primarily for either SEAD operations against mobile threats along extensions of LLTRs (See Annex D) or for point suppression to destroy known fixed sites. However, they can also be tasked to provide direct support to a mission.

b. **Raven.** When tasked for stand-off jamming (SOJ) the flight profile will place the aircraft, usually a pair, just outside SA-12 range, in a 40 nm orbit at 15-25,000 ft. The Close-in Jamming (CIJ) profile, to provide a corridor for penetrating missions, places the aircraft close to the FLOT (20 nm from the FEBA) at up to 5000 ft (See Annex D). The aircraft is capable of night operations, but due to the limited assets being assigned primarily to day OCA sorties, night tasking is unlikely. Similarly, while the Raven can provide deep rear area jamming, it will be tasked to penetrate the FEBA only for the highest priority COMAAFCE directed missions.

c. **Compass Call**. Compass Call is employed in SOJ orbit areas, beyond the range of long range SAMs. The jamming priorities will depend on the type of missions being supported. It has a large ECM footprint and can provide simultaneous support to numerous missions and mission types. However, it is very vulnerable to enemy engagement, requires extensive mission preparation time, is slow to deploy and may interfere with friendly communications.

FIGHTER SUPPORT

20.(S) (Reference COMAAFCE COMAO SOPs) Various fighter protection options are available to support an attack package of which pre-attack sweep and escort are the 2 basic options.

AEW SUPPORT

21.(S) (References COMAAFCE 35001D and COMAAFCE COMAO SOP). NAEW assets can provide support to offensive air operations provided that it does not interfere with their primary tasks. Support is likely to be limited to a threat broadcast (giving simply a Grid position and Bandit/ Bogey/ Chick indication) stretching up to 60 - 80 nm beyond the FLOT. However, if the situation allows then additional information may be provided such as: magnetic heading of bandit, size of formation, altitude and speed. AEW may also assist with AAR RV, give navigational assistance, broadcast base information etc.

AAR

22.(S) AAR is normally only available to squadrons operating from the UK and they are well versed in the procedures covered in 1Gp AAR SOP. However, it bears stressing that although the tanker fleet is having its fuel uplift capability improved, it will remain a severely stretched resource whose priority task will be to support the air defence effort. Therefore, consideration should be given to making contingency plans should AAR not be available.

INTELLIGENCE

23.(R) The importance of accurate and timely intelligence, disseminated to the user, cannot be over stressed. It is therefore incumbent on all to report expeditiously any gleaned intelligence and to ensure that personal knowledge of intelligence matters is as current as possible.

MISSION REPORTS

24.(R) **In-Flight Reports (IFREPS)**. (Reference AAFCE Manual 80-2). IFREPs are the standard method whereby crews report mission results whilst in flight. This report is also to be made whenever tactical information is observed that is of such importance and urgency that delay, if reporting by normal debriefing, would negate the usefulness of the information.

25.(R) **Mission Report (MISREP)**. (Reference AAFCE Manual 80-2) For all Attack, Strike and Support missions, MISREPs must be transmitted within 30 minutes of engine shutdown to inform the tasking agency of the results of the mission. In order to meet this timescale, it is important for crews to relay their message to their Wing Operations Centre as soon as possible after landing. Significant data from a mission, over and above the requirements of a standard MISREP, may be available (including possibly a

CVR tape); this data should be passed to a debriefing officer as soon as possible after the mission. Also, squadrons should consider passing intelligence gained from missions to each other.

INTENTIONALLY BLANK

ANNEX A TO
SECTION 5, CHAPTER 1 OF
TORNADO GR1 TACTICS MANUAL

AIR REQUEST TASK MESSAGE

CLASSIFICATION NATO			DTG			
PRECEDENCE ACTION : INFO :	INTERNAL COORDINATION					
FROM :	INFO :					
TO :		MESSAGE INSTRUCTIONS TABULATE				
		SIC				
	EXER / OPER :					

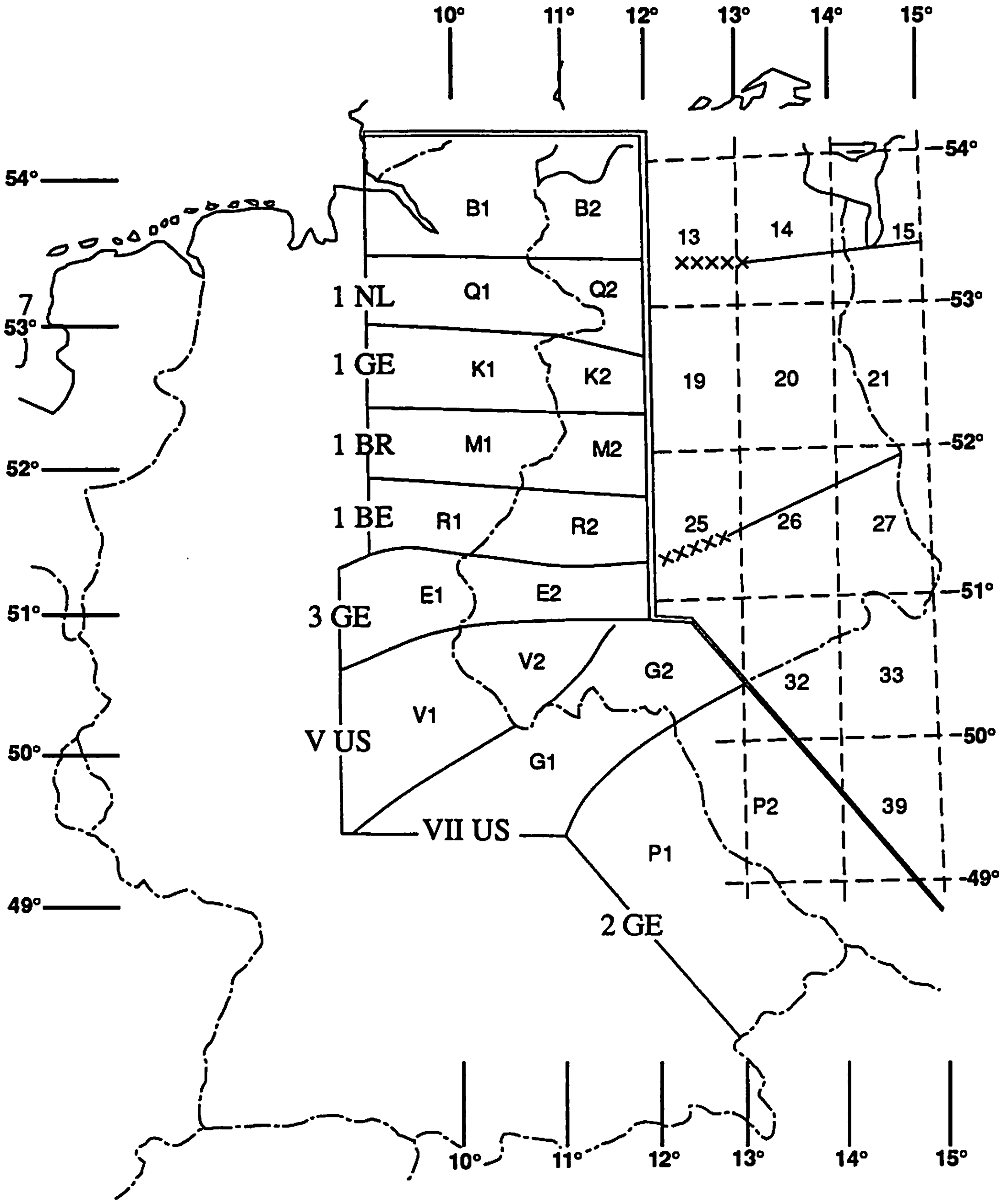
NOT FOR TRANSMISSION		A. 1- AIR REQUEST TASK MISSION NO :	
A - 2		A. 2- A CAS B BATTLEFIELD INT C INT D COUNTER AIR E RECCE F EW G ESCORT H	
A - 3		A. 3- A ARMED RECON B HARASS C NEUTR D DESTROY E JAM F DEF SUPP G CHAFF H SLAR J TEREC	
A - 4, 5 & 6 TGT DETAIL (PASS INFO IN FOLLOWING ORDER PER TGT) - TGT / LINE NO - LOCATION - DESCRIPTION / CATEGORY - CLASSIFICATION	* PRIORITY	A. 4-	*
		A. 5-	
		A. 6-	
B TOT		B- Z ☐ ASAP NLT Z	
C POSITION OF FRIENDLY TROOPS		C- ☐NIL	
CONTROL DETAIL D.1 (INITIAL RADAR) C/S+FREQ		D.1- P S	
D.2 (FWRD RADAR) C/S+FREQ		D.2- P S	
D.3 (TACP/ASOC) CP+TAD/FREQ		D.3- CP P S	
D.4 (TACP/ALO) CP+TAD/FREQ		D.4- CP P S	
D.5 (TACP/FAC) TAD/FREQ		D.5- P S	
D.6 CP/OP/IP		D.6-	
D.7 MARKERS, SMOKE, PANEL, LASER FREQ, ETC		D.7-	
E INFLIGHT REPORT		E- P S	
F SQUADRON/WING		F-	
G NO. & TYPE AIRCRAFT		G-	
H SCL/SENSOR		H-	
J REMARKS E.G.: ALT TGT/ MSN SPT DATA/ REPS/AERIAL REFUEL DATA		J-	
		ATC RULES APPLY EXERCISE	

COPIES TO : COMM CTR ☐ CURRENT OPS ☐ INT ☐ OTHER ☐	ARMY ☐ ATTACK ☐ RECCE ☐ EW ☐	RCVD DTG Z	INITIALS	DRAFTER TEL NO
		TRAN DTG Z	INITIALS	RELEASER TEL NO

INTENTIONALLY BLANK

ANNEX B TO
SECTION 5, CHAPTER 1 OF
TORNADO GR1 TACTICS MANUAL

TYPICAL OAS ARS AND OCA TARGETING AREA



INTENTIONALLY BLANK

ANNEX C TO
SECTION 5, CHAPTER 1 OF
TORNADO GR1 TACTICS MANUAL

SUPPLAN MIKE - AIRSPACE MANAGEMENT

1.(C) Examples of the Supplan Mike Management Areas are illustrated in Figure 5-1C-1. The definitions (and Abbreviations used) are given at para 2.

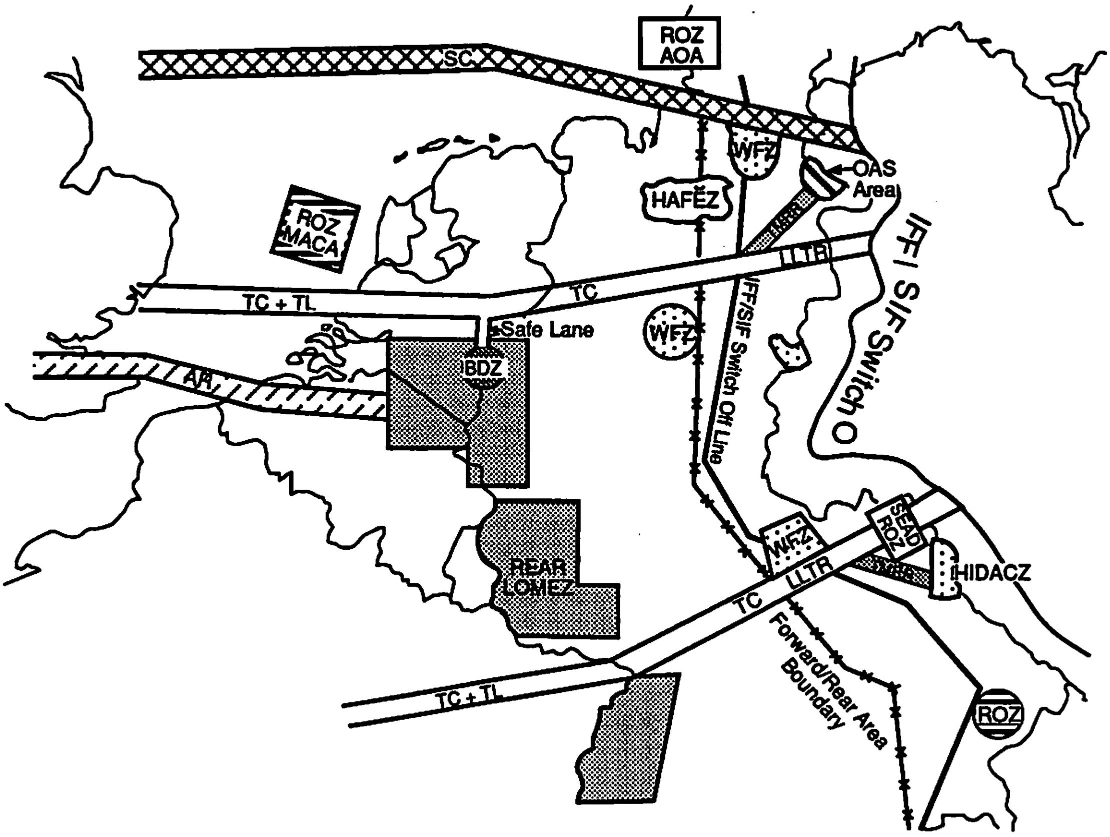


Figure 5-1C-1 (C) - Typical SUPPLAN MIKE Management Areas

2.(C) **Airspace Management Definitions.**

a. **Air Route (AR)** - A route established to feed Operational Support and Non-operational air traffic through air defences in the rear area.

b. **Amphibious Objective Area (AOA)** - A geographical area to be secured by the amphibious task force and within which C^2 procedures are in force over land, sea and air operations.

c. **Base Defence Zone (BDZ)** - An air defence zone established around an airbase and limited to the engagement envelope of the GBAD assets defending that base. Traffic is to utilize Safe Lanes and to comply with local procedures or No-Radio Recovery Procedures.

d. **Coordination Level** - An advisory level to give some separation between slow and fast moving traffic. However, collision avoidance remains "see and avoid".

e. **Forward Area**. For Airspace Management purposes the Forward Area is identified as that area between the IFF/SIF switch-on line to the east and the rear boundary of the forward area to the west.

f. **High Density Airspace Control Zone (HIDACZ)** - A volume of airspace over a geographical area within an Army Corps sector used for the coordination of air and ground operations. Prior approval is required to penetrate the HIDACZ.

g. **Hostile Aircraft Free Engagement Zone (HAFEZ)**. The CR is divided into zones termed HAFEZ. These zones will be selectively activated, based upon expected enemy ingress routes and possibly prior to General Alert, to allow mass employment of SAM/SHORAD to inflict maximum attrition against initial large scale hostile air attack. All aircraft within a HAFEZ are automatically declared hostile and identification is not required. Therefore, do not enter a HAFEZ.

h. **Low Level Transit Route (LLTR)** - A 10km wide route established to allow friendly aircraft through the ground based air defences in the forward area with minimum risk.

i. **Maritime Air Coordination Area (MACA)** - The area surrounding a force at sea within which air coordination is required.

j. **Minimum Risk Levels**. Minimum risk levels are established to allow operational air traffic to traverse the forward and rear areas, without lateral restrictions, for the 24 hr period following ERT. It is automatically activated and therefore will **not** be reflected in the ACO.

k. **Rear Area** - That area to the rear of the Forward Area which includes the Communications Zone and the rear of the Combat Zone.

l. **Restricted Operations Zone (ROZ)**. The ROZ provides controlled airspace for specific activities, eg AAR, SEAD and terminal approach holding areas.

m. **Safe Lanes** - Established to route aircraft on arrival and departure between airbases and the adjacent activated routes/corridors.

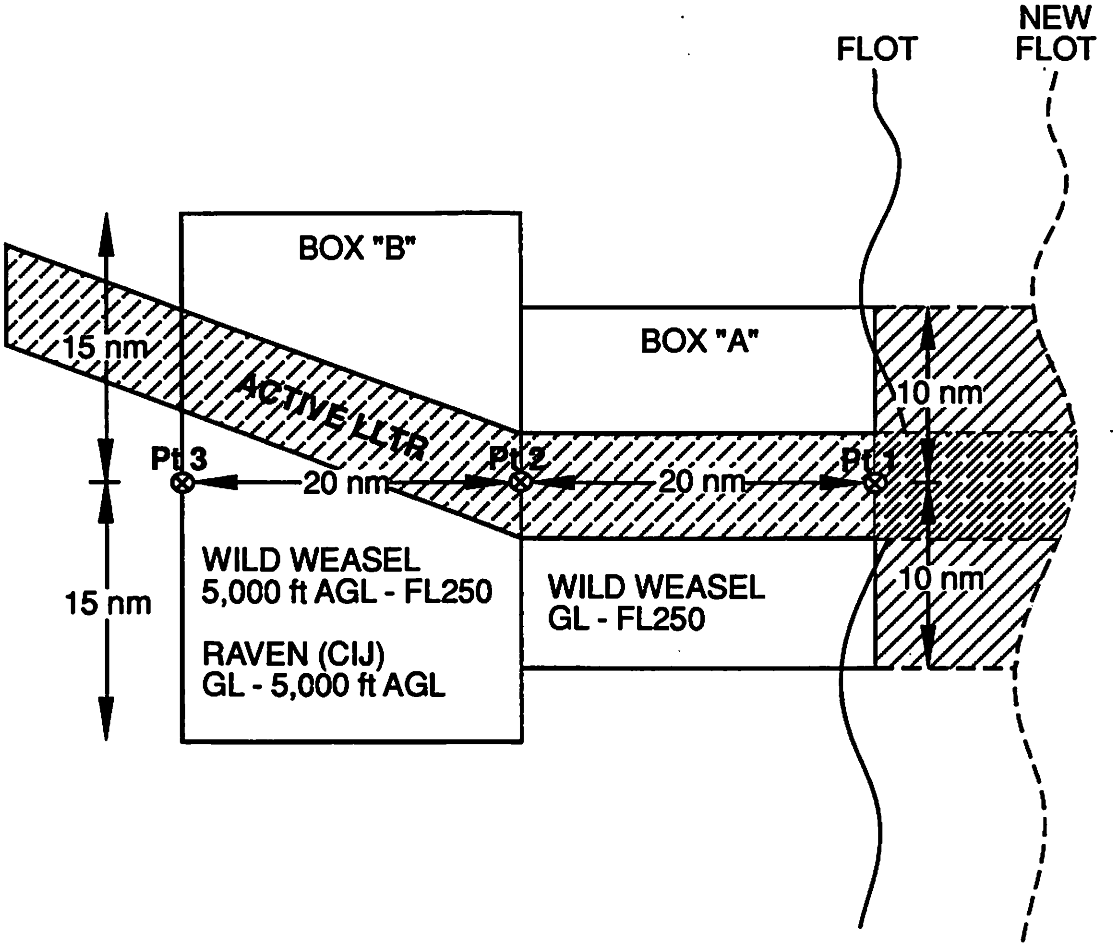
n. **Special Corridors** - Established to accommodate routeing requirements of large formations or special missions unable to use the planned routes.

o. **Transit Corridor (TC)** - Established to route Operational Combat traffic and specific Operational Support traffic through air defences in the Rear Area.

p. **Temporary Minimum Risk Route (TMRR)** - Established to route aircraft between LLTR or the rear boundary of the Forward Area and their operational areas in direct support of the Army ground battle, eg CAS, Paradrop or Medevac.

q. **Weapons Free Zone (WFZ)** - An air defence zone established for the protection of key assets or facilities, other than airbases, eg bridges, command posts and SAM/Radar sites. They must be avoided when active.

SEAD BOX DIMENSIONS



NOTE

In the event of an "Easterly" movement of the FLOT during the period of validity of an ACO, the Eastern boundary of the Wild Weasel Box will automatically extend to the new FLOT (see shaded area on Diagram).

INTENTIONALLY BLANK

CHAPTER 2 - WEAPON TO TARGET MATCHING

INTRODUCTION

1.(R) When given a target to attack, the first decision required is the selection of the most appropriate weapon system available. To allow this decision to be made and to ensure the successful and economic employment of aircraft weapon systems, using conventional ordnance, requires a full appreciation of the vulnerability of various targets to the available aircraft/ weapon combinations (see also the CWEM and AP3456H).

2.(R) The weapons available for use by the Tornado for conventional ground attack options are discussed in this chapter and are as follows:

a. JP233.

b. UK 1,000 lb HE (MC) - Retard and Freefall (FF).

c. Laser Guided Bomb - Paveway LGB.

d. Cluster Bomb Unit (CBU) - BL755.

e. 27mm Mauser Cannon.

f. ALARM.

g. NATO Weapons - used with Minimum Area Crutchless Ejector (MACE).

3.(R) This chapter highlights some of the problems associated with attacking OCA, AI and BAI targets together with some types of targets of opportunity. A weapon-to-target matching guide is at Annex A.

WEAPONS

JP233

4.(S) The JP233 weapon system was designed specifically to deny operations from enemy airfields by inflicting damage to take-off and landing surfaces of up to 400 mm vertical thickness. The weapon is also suitable for certain types of interdiction targets, eg approaches to bridges and railway-yards, but it is unlikely that they would be released for such tasks. The damage is achieved by using two types of sub-munitions (SM), namely cratering devices (SG357) enclosed within a pattern of area denial devices (HB876). The weapon system is of modular design with the cratering devices and area denial SM loaded separately onto the aircraft but faired to form one JP233 unit. The Tornado can carry one or two such units mounted on the shoulder pylons. Each unit contains 30 SG357s and 215 HB876s; the latter arming 15 min after release to detonate either when disturbed or at random intervals up to 12 hr later. Ninety-four JP233 weapons were delivered by RAF Tornado aircraft during operational missions on Operation GRANBY; a factual record of these JP233 missions has been produced by the ORB, HQSTC (NFR 9/91 dated Nov 91).

5.(S) **Effectiveness of SMs.** The success rate achieved during Trial TYNE 4 for SG357 SMs were 65% and 95% for short (across) and long (along) sticks respectively; these compare with estimated rates from imagery of 79% and 82% during Operation GRANBY. The success rate for HB876 SMs achieved during Trial TYNE 4 was an overall 91%; it was not possible to estimate of success rate for the operational delivery of this SM. Subsequent drops of JP233 at West Freugh, completed as part of the on-going surveillance programme, have supported the results obtained from both

Trial TYNE 4 and Operation GRANBY. However, the success rates referred to above only relate to the correct functioning of both primary and secondary charges whereas the overall effectiveness of the SG357 SM also depends upon target thickness, structure of subsoil, stick length set, release height and surface wind. These aspects are expanded below:

a. **Target Thickness.** The runway damage mechanism is for the SG357's primary charge to place the secondary charge beneath the surface. On detonation, this secondary charge not only makes a crater through blast but more importantly causes the surrounding area to heave. The heave is difficult to repair, and thus the thickness and the type of operating surface that the primary charge can penetrate effects overall SM effectiveness. The implications of strengthened runways on the effectiveness of the SG357 SM was investigated by RARDE in 1989 (Trial BEAST); the performance of this SM was found to be degraded. However, a subsequent study to quantify the operational effects was carried out by STC ORB (ORB Memo 2/90 dated Jun 90) noted that with the reduction in effectiveness of the SG357 SM, the effects of the HB876 SM gained in importance.

b. **Structure of Sub-Soil.** If the sub-soil is particularly soft, eg soft sandy sub-soil as found in Iraq at Jalibah SE and Tallil, the effects of the SG SM may be reduced. A soft sub-soil will allow the secondary charge to be implanted more deeply than would normally be expected; this factor, together with characteristics of the sub-soil, may cause much of the force of the secondary charge to be absorbed or funnel the force through the original hole made by the primary charge. As a consequence, although the runway surface cracks it may not lift and heave.

c. **Stick Length.** Two stick lengths, nominally 650 m and 2,600 m, are selectable from the cockpit. A delivery speed of 450, 500 or 550 KCAS must be set on the speed band switch on the weapon before take-off and deviations in release speed from the set speed will affect the final stick length. The speed band switches are actually timer selections, thus with a 450 KCAS speed band set, for example, short and long sticks would take 2.9 and 11.4 sec to be completed (ejection time intervals for each speed band are given at Annex B). A variation between speed band setting and actual delivery speed will not affect the time to deliver the stick but will vary the stick length achieved. However, selecting a speed setting faster than the planned attack speed is not recommended for short stick attacks as this will reduce the distance between SG357 SMs, probably increasing interference and hence further reducing the SM success rate. Also, if the speed setting is other than the planned attack speed, when centre-stick aiming is used, the SMs will be asymmetrically placed about the aiming point. The theoretical spacing between SG357 craters is 11 m for the short stick and 44 m for the long stick. However, the across stick dropped on Trial TYNE 4 gave inconsistent stick spacing caused by in-flight interference between the SM and subsequent dudding; the largest gap between craters was 105 m - certainly enough to "miss" a runway. Encouragingly though, the partial SG357 drop (20 SMs) in the along track mode achieved acceptable spacing and a single dud was caused by a manufacturing problem. The stick patterns achieved on Trial TYNE 4, which used latest production standard SMs, are at Annex C.

d. **Release Height.** The ideal delivery height is 200 ft (60 m), but the weapon can be delivered, although with decreasing effectiveness, down to 100 ft (30 m) as shown at Annex D; it has zero success below 100 ft. So, although a lower release height will provide a measure of protection from airfield defences, it would require the use of more aircraft to deliver the same number of effective SG 357 SMs.

e. **Wind Effect.** As the surface wind increases, the success rate for emplacing the secondary warhead decreases because of weapon drift after the primary (hole boring) charge has fired. Indeed, above the critical wind speed, the SM effectiveness rapidly falls to zero. Annex D shows the variation of critical wind speed for different release heights and target thicknesses; it is also worth noting that the success rate of the SMs will be higher for a given wind speed when released from a greater height.

Not withstanding the degredation in penetration capability of the SG357 SM against reinforced runways, JP233 remains a most valuable weapon because of the difficulties of clearing the considerable number of HB876 units that any raid would lay down. The ORB still consider that the synergistic effects of SG357 and HB876 SMs could halt flying operations on an airfield if delivered accurately.

1000LB HE (MC) BOMB

6.(R) The UK 1,000lb HE (MC) bomb is a versatile, effective weapon and its performance is enhanced considerably with the introduction of the Mk960 Multi-Function Bomb Fuze (MFBF). With the older fuzes, the weapons are prepared for either FF or retard use before being loaded to the aircraft. However, with MFBF the function of the tail and fuze can be changed on bombs already loaded, albeit only on the ground. A description of MFBF is contained in the Tornado Aircrew Manual, Book 2, and in its classified supplement (CD101B-4101-15B).

7.(C) **Tails.** Two types of tail, Mk114 (FF) and Mk117 (Retard), are available for the 1,000lb bomb although very few of the former remain. During Trial WRENTHAM the loft delivery of Mk117 tails, with the retard mechanism inhibited, was examined; it showed that there was little difference in ballistic performance from the Mk114 tail. However, during a subsequent trial of ripple-pairs releases from a full loft manoeuvre in an 8-bomb fit, the retarder partially deployed on one bomb which subsequently tumbled clear of the others and impacted some 2 nm short of the target. This may have been caused by disturbed airflow associated with the twin-store carriers and an investigation is currently in progress. On Tornado the maximum speed limit for carriage of bombs with Mk117 tails is 600/0.92 KIAS/Mach but, depending upon configuration, more stringent release speeds may apply.

8.(C) **Penetration Cabability.** It is worth noting that the design specification for the UK 1,000lb HE(MC) bomb requires the weapon to be capable of penetrating 24 in of concrete. For greater thicknesses the bomb will start to deform and break-up which will clearly reduce its overall effect. Fuzing against hardened targets should be selected to allow the bomb to penetrate to its maximum depth before the bomb deformation has an effect. The velocity of the bomb on impacting the target can also have a significant influence on the overall weapons effect. Break-up is likely to occur with impact velocities in the order of 1,000 ft.sec^{-1} (592 kn). The problem of ricochets must also be considered and this is highlighted in Figure 5-2-1. The diagram shows that penetration of hardened surfaces is unlikely to be achieved by a FF 1,000lb bomb unless the impact angle exceeds 65°. There is a grey area between 55° and 65° - not shown on the diagram - where penetration might occur. FF or retard 1,000lb bombs should penetrate soil if impact angles of about 24° or 30°, respectively, are achieved. **Note:** These values were obtained from the CWEM.

Practical experience gained during both SEDGE 2 (see para 10 below) and Operation GRANBY indicate that Figure 5-2-1 is pessimistic. For example, it is not necessary to have an impact angle in excess of 75° to achieve successful penetration of a hardened target.

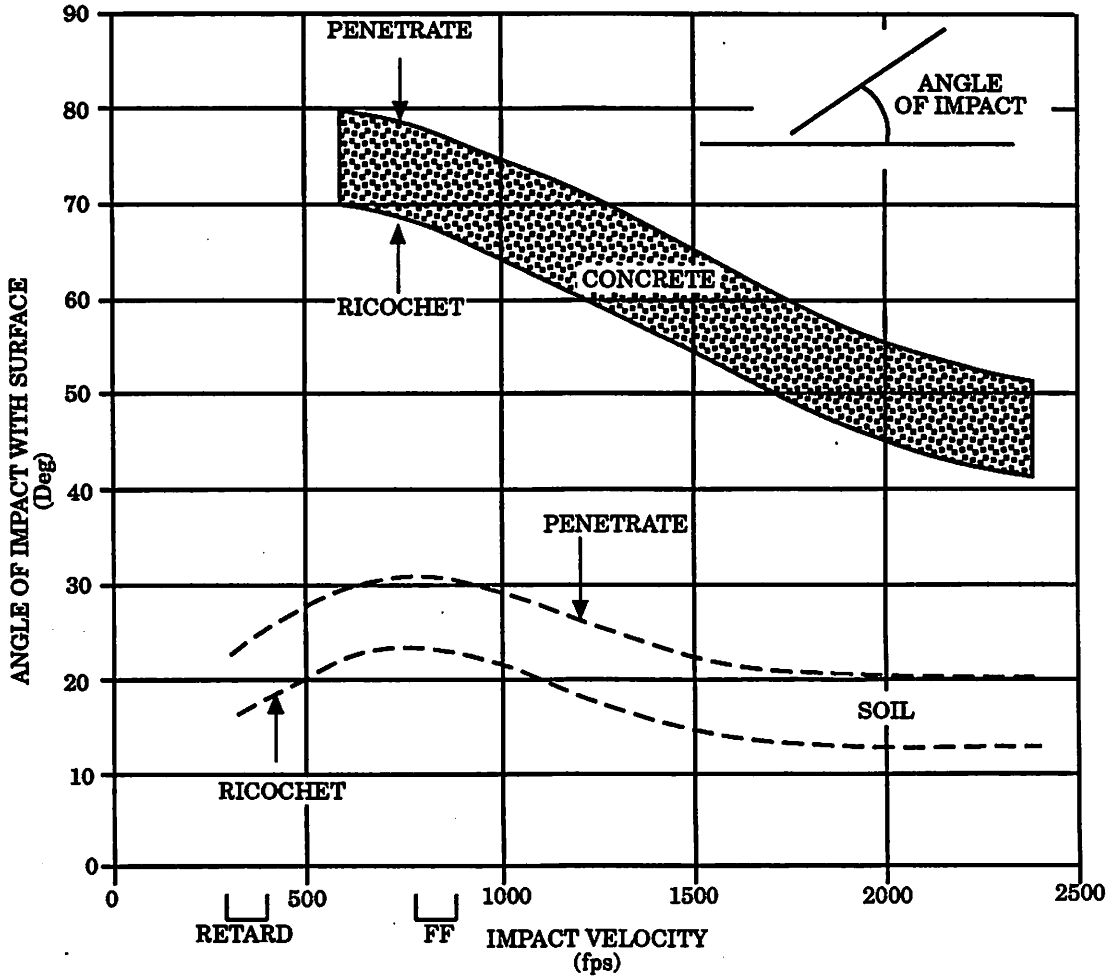


Figure 5-2-1(C) - Ricochet Conditions for Concrete and Soil

9 (R) **Impact Data.** Typical operational weapon impact data for laydown, loft (low and mini) and medium altitude deliveries is shown in Table 5-2-1. The expected operational impact patterns from low level delivery profiles have been determined during flight trials and are shown at Annex E. Impact positions for medium altitude deliveries will be determined during Trial FENIT which is due to take place in late 1993.

Serial (a)	Attack Mode (b)	Bomb (c)	Release Angle (d)	Release Speed (Knots) (e)	Impact Velocity (ft/sec) (f)	Impact Angle (g)
1	Laydown	1,000lb	0	500	338	12.0°
2		Retard	0	550	345	11.6°
3			-5°	500	305	20.0°
4			+5°	500	200	35.0°
5	MiniLoft	1,000lb	+7°	500	816	12.3°
6		Freefall	+7°	550	883	11.8°
7	LowLoft	1,000lb	+30°	500	818	38.0°
8		Freefall	+30°	550	870	37.5°

Table 5-2-1(R) - Typical Operational Weapon Impact Data

10.(S) **Weapons Effects with MFBF.** Deliveries against hard targets with MFBF were carried out during Trial SEDGE 2. Those using a delayed fuze setting often resulted in a ricochet and caused an airburst effect on deliveries up to 30° dive angle (theoretical impact angle for 30° releases at 3,500ft is 43°). Low loft (25°- 30°) attacks with instantaneous fuzing created 'shallow' cratering 9 ft long, 8 ft wide and 2 ft deep with 3 to 6 in of heave against a 12 in concrete runway. Most laydown retard deliveries with delayed fuzing ricocheted and culminated in an airburst. Laydown retarded instantaneous deliveries caused 'shallow' cratering 9 ft long, 9 ft wide and 2 ft deep but with minimum surface heave. Weapons released from a 30° dive, with a 20 ms delay and which penetrated the concrete runway, created a crater 20 ft long, 17 ft wide and 4 ft deep with good heave (12 in) on all surrounding blocks with 25-30 ft radial cracks. However, on other occasions, the weapons ricocheted off into soft sand. Finally, a 45° delivery (theoretical impact angle of 60°) impacted and penetrated a runway target using a long delay. The result was a crater of 39 ft diameter which was 10 ft deep, with up to 2 ft of heave all around the crater and with 6 in x 6 in fragments located up to 250 ft from the centre. It is therefore recommended that dive angles in excess of 30° are used when medium altitude steep dive tactics are used, preferably 45° dive attacks. Fuzing information for MFBF is shown at Annex F and is extracted from the JMEM, the CWEM and the Trial SEDGE 2 report.

11.(C) **Delivery from Medium Altitude.** A major concern when considering bombing from medium altitudes - apart from the capability of the enemies defences - is the anticipated weapon delivery accuracy of which the contribution made by any error in the height system of the delivery aircraft can be the most significant. For example, although height induced errors would tend to cancel each other out for Phase 2/3 attacks, they would be cumulative for Phase 1 attacks and any system error would lead to a miss distance in excess of 100 ft for every 100 ft of height error. An evaluation of medium altitude dive and level bombing, including weapon aiming techniques, was carried out during Trial COBNUT. A summary of the recommended procedures is given in Section 9 of this Manual. Further assessments are to be carried out by CTTO during 1993 as part of Trials FRAPPE, FEAGARRIED and FENIT.

PAVEWAY LGB

12.(R) LGBs were delivered from medium altitude during Operation GRANBY with considerable success, using both PAVESPIKE designators and pre-production TIALD systems. Details of the UK 1,000lb HE (MC) bomb fitted with the PAVEWAY LGB kit can be found in AP 3456H. The LGB can be fitted with MFBF; therefore, much of the information on the 1,000 lb HE (MC) bomb and MFBF contained in the preceeding paragraphs is also relevant to the LGB. Advice on delivering LGBs is contained in HQ 2 Gp PAVESPIKE/ PAVEWAY SOPs, the trial reports for Trial TAPSTER (A&AEE NR Letter Report dated Dec 85), Trial COSHAM and Trial ALBERT, and in Section 9 of this Manual. Of note Trial COSHAM addressed medium level operations while Trial ALBERT was devoted to TIALD.

BL755

13.(R) BL755 with SAFU settings of 0.68 and 1.13 sec may be used. Details of BL755 can be found in AP 3456H.

MAUSER CANNON

14.(C) The Mauser cannon is a fully automatic, gas operated, electrically fired weapon with a revolver action, firing linked ammunition of 27mm calibre; more details on the gun can be found in the Tornado Aircrew Manual, Book 2. High Explosive (HE) and Armour Piercing High Explosive (APHE) ammunition is cleared for use in a one-to-one mixed belt known as ~~[illegible]hot.~~ SEQUENCE BELTED

ALARM

15.(S) The air launched anti-radar missile (ALARM) is a defence suppression weapon designed to destroy or disable threat radar systems associated with SAM and AAA; up to 9 missiles can be carried by Tornado. The missile was introduced into service ahead of schedule for operations during Operation GRANBY during which 104 were fired with mixed success. A detailed description of ALARM and its modes of operation can be found in the Tornado Aircrew Manual, Book 2. ALARM SOPs are covered in Chapter10.

NATO WEAPONS

16.(C) The CBU-58/CBU-87 (cluster bombs), the Mk82 500lb bomb fitted with the Mk15 Snakeye (high drag) tail or the BSU-49 Air Inflatable Retarder and dropped in either the retard or FF modes and the GBU-12 (Mk82 LGB) and GBU-24 (Mk84 LGB) are cleared for WAR ONLY use. The Mk20 Rockeye CBU is not cleared because a wiring conduit on the upper surface of the casing makes it incompatible with MACE. Additionally, there is a proposal to clear other series Mk80 bombs for use by Tornado. However, to enable

9L2 (M5)

Tornado to carry these weapons, MACE saddles would also have to be pre-positioned at the loading airfields; also, current software does not include ballistic information to allow accurate weapon aiming.

OCA TARGETS

17.(S) The aim of OCA operations is to cause severe disruption of airfield facilities and operations, and if possible cause the destruction or neutralisation of a hardened MOB. To this end, attacks against the following DMPIs should be considered:

a. Airfield Targets.

b. Radar Targets.

c. SAM Targets.

AIRFIELD TARGETS

18.(R) Where DMPIs are not specified in the ATM, attacks should be directed to degrade enemy sortie generation rates to the maximum extent. The decision to attack aircraft operating surfaces (AOS), HAS complexes or other airfield installations will depend on many factors which include:

a. The total number of operating areas available on an airfield which are capable of supporting a MOS and the length of the MOS.

b. The structure of the AOS and their thickness.

c. Tactical considerations, for example the availability of good (and accurate) visual/radar identification features and the disposition and density of airfield defences.

d. Anticipated delivery errors.

e. The number of aircraft available to execute the attack.

19.(S) **AOS.** Many ex-Soviet aircraft are capable of operating from taxiways and grass strips. Annex G gives data on the minimum required take-off surfaces for Soviet fighter type aircraft. Typically ex-WP runways are made of concrete some 300 to 400 mm thick with dimensions of 2500 x 60 m (8200 x 200 ft); some of these were believed to be refurbished giving a total thickness of up to 800 mm of concrete (HQSTC ORB Memo 2/90 dated Jun 90 refers).

a. **JP 233.** A JP233 delivered along a runway would effectively neutralize the surface for a considerable period of time; however, tactical considerations may preclude this delivery option. Furthermore, consideration must also be given to possible delivery errors in angle, line and range; a plan to provide shallow angle cuts on the runway which in practice cuts at least some section of the runway may be preferable to along runway attacks which may be totally ineffective if poorly executed. Therefore, it may be preferable to plan across attacks (short stick) to make oblique cuts across the operating surfaces such that no possible minimum operating strips (MOS) are left. The number of cuts required to eliminate all MOS is dependent upon the disposition of operating surfaces, the lightweight take-off performance of aircraft based at the subject airfield and the gap between craters. As an example, a FLOGGER with weapons and half fuel requires an estimated minimum take-off strip of 560 x 15 m. Therefore, a minimum of four cuts would be required across a 2,500 m runway to deny a suitable take-off area. However, the probability of a successful cut across the runway depends not only on the SM success rate but also the stick spacing. Annex H shows the probability of runway closure for a short stick with differing numbers of aircraft and varying SM success rates (assuming a 45 m wide runway and an across attack at 90° to the runway), while HQSTC ORB NFR 8/91 dated Jun 91 provides a quick guide to the number of SMs which will fall on AOS for various cutting angles (assuming theoretical stick spacings). However, in practice the SMs are subject to clumping and the stick patterns are unlikely to be regular (see para 5c to this Chapter. To ensure complete coverage the cuts must also include taxiways and, if applicable, grass operating surfaces; if possible the ends of the sticks should fall within HAS sites, ATC, C^3I, ammunition storage areas or logistic areas to maximize the confusion caused by the attack. Along runway attacks could be used to supplement the across runway attacks. A third option for attacking an airfield with JP233 is to cut the accesses to HAS complexes and/or aircraft dispersals; this was done with some success during Operation GRANBY, for example at Tallil and Mudaysis, using short sticks. It is worth remembering that the threat from the HB minelets is greater from short stick deliveries because the SMs are more closely concentrated; however, short stick attacks are more sensitive to delivery errors. A summary of JP233 airfield targeting considerations is given at Annex I.

b. **1,000lb Bomb.** FF and retard 1,000lb bombs with forged cases can be used against runway surfaces, although retarded weapons are likely to cause minimum damage (para 10 refers). Even so, peripheral damage will be caused by instantaneous fuzed bombs which has become more significant with the introduction into service of the more rapid reacting MFBF. Peripheral damage, when penetration is achieved, consists mainly of concrete heave and cracking over a wide area around the crater; the extent of any heave is determined by the depth of penetration and the speed of impact. The cratering effect of either the 1,000lb FF or retard bomb against natural surfaces is similar to that obtained by the FF bomb against concrete - a crater with a diameter in the order of 30 ft.

c. **LGB.** AOS were attacked with UK 1,000lb LGBs from medium altitude during Operation GRANBY with some apparent success although, in general, AOS suffer from poor laser reflectivity and have no vertical extent. Furthermore, runway surface DMPIs are limited by the lack of visually significant aiming points and runway intersections are therefore desirable.

d. **BL 755.** The effects of BL755s on concrete surfaces have been assessed by RARDE and the damage obtained in terms of cratering is considered insignificant. However, although each bomblet only produces a scrape some 16 in x 12 in x 3.5 in deep, the overall effect is to leave a considerable amount of dispersed rubble. Thus cluster bomb attacks are likely to harass and create a considerable sweeping requirement with the hazard of unexploded bomblets adding to the repair time. It has been estimated that it would take one man 10 min to repair one hole made by a bomblet and a further 30 min for the concrete to set, although emergency take-offs may be possible from the pitted concrete runway after only sweeping had been completed. (Note. A combination of retarded 1,000lb and cluster bomblet craters could create a number of short-term problems, which would be exacerbated by a mixture of long and short delay fuzed 1,000lb bombs dropped during the same raid).

20.(S) **HASs/COCs.** Weapon effects applied to HASs are taken to apply equally to COCs and PBFs.

a. **1,000lb Bomb.** Within a HAS complex, use of the PBF as the DMPI could severely disrupt operations especially if it is in the centre of the complex. Sticks of 1000lb bombs aimed at the PBF would also cause collateral damage elsewhere in the HAS site. Laydown, Low-Loft and Mini-Loft attacks should be considered as complimentary options when planning an airfield attack,. Shelters attacked with 1,000lb bombs are immune to all but a direct hit. A bomb would need to penetrate any earth or sand covering and explode close to the concrete structure to cause internal damage.

(1) **Retard Bomb.** Generally sticks of retard bombs can be delivered with greater accuracy than FF bombs. From a typical laydown delivery only about 5 ft of the soil covering would be penetrated. The most vulnerable area is the doors. Even if the doors were hit it is estimated that retard bombs will barely penetrate the spaced structure because instantaneous impact fuze settings would normally have been used. Retard bombs impacting in the vicinity of the doors or the concrete approaches to the HAS could disrupt operations and possibly cause blast damage to aircraft or personnel inside the HAS or COC. From Tornado, retarded bombs within sticks cannot be released as pairs and the minimum release interval between successive bombs is comparatively large.

(2) **FF Bomb.** Previously aircraft could only harass an area target using loft/toss type attacks but now Tornado offers a 'point harassment' capability. Accuracy with Tornado Low Loft and Mini-Loft deliveries (for Tornado, releases under 'g') is such that a HAS type DMPI could feasibly be selected even in non-visual conditions. Whilst all lofted FF bombs have sufficient striking velocity to penetrate 27 ft of earth, Mini-Loft attacks are thought to be one of the best methods of damaging a PBF because of the increased aiming accuracy; bombs that miss or ricochet should cause some cratering elsewhere in the shelter complex. Medium level deliveries, both level and dive, are feasible against HAS complexes providing the defences are minimal or suppressed. Apart from tactical considerations, the likely delivery errors for level attacks must be considered which would probable be worse than those for Mini or Low Loft. Lastly, the weather conditions must be right for Phase 2/3 dive attacks - the pilot has to be able to see the target!

b. **LGB.** The problems associated with designating targets for LGB attacks deep inside enemy territory are likely to prevent their use against HAS complexes - or are they? LGBs were delivered from medium level against hardened buildings with considerable success during

Operation GRANBY using both TIALD and PAVESPIKE designators, showing the worth of this type of weapon in an environment where the defences are light or can be suppressed. HQSTC ORB has assessed that an attack along the major axis of the HAS (ie axis through main door and HAS rear), and aiming the weapon mid-way along the HAS, will create the greatest level of damage. LGBs use the 960 fuze and weapons effects are similar to those of 1,000lb FF bombs. As already highlighted at para 8, the bomb will start to deform and break-up if its impact velocity is too high and the target thickness is too great thus reducing its effectiveness; therefore, the fuzing time is critical. For example, against a concrete HAS or PBF/COC, with no earth or sand covering, the following fuze settings have been determined from a MOD sponsored trial at RARDE which took place in 1990:

(1) At over 850 ft.sec^{-1} velocity, against a concrete target thicker than 24 in, a bomb can be expecred to start to break-up on impact; therefore, it is estimated that the maximum fuzing time should be 1.5 ms.

(2) Between 850 ft.sec^{-1} and 750 ft.sec^{-1}, against a target greater than 24 in thick, the bomb should be expected to suffer anything from distortion to break-up; therefore, the maximum fuzing time should be 2.5 ms.

(3) Under 750ft.sec^{-1}, bomb survival can be expected and therefore the fuzing time selected should allow the bomb to penetrate to its maximum depth (up to 48 in) before detonation.

(4) For targets less than 24 in thick, at angles up to 30° off normal and velocities up to to 985ft.sec^{-1}, the bomb should survive impact; fuzing time should be a minimum of 10 ms to allow the bomb to penetrate fully but can be increased further if required.

The effect noted during both Trial SEDGE 2 and Operation GRANBY indicate that the above limitations on the performance and capabilities of the UK 1,000 lb bomb appear to be pessimistic.

c. **BL755.** BL755 bomblets will only penetrate 3 feet of earth and therefore are completely ineffective against shelter sides. However, the probability of hitting a door is estimated to be 20% from a low-level delivery. While the bomblet's jet will penetrate the door the damage inflicted on an aircraft inside the HAS, although difficult to assess, is estimated to be of a low order and would be negligible if the door cavities were filled. BL755 is therefore assessed to be little more than of nuisance value against HAS complexes.

d. **27 mm Cannon.** It is not known whether the 27 mm HE or APHE shell will have sufficient energy to penetrate the spaced steel place construction of a shelter door. Attacks on HAS with 27 mm cannon are not recommended as being worthwhile as the chances of achieving a successful attack are outweighed by aircraft vulnerability to the airfield defences during the attack.

21.(S) **Aircraft.** Aircraft on the ground can be protected by dispersion in revetments, shelters, decoys and also by camouflage. Aircraft outside shelters are vulnerable to all the weapons carried by Tornado. However, acquiring such targets to carry out an accurate attack in a defended environment is likely to be difficult.

a. **1,000lb Bomb**. The 1,000lb FF and retard bombs fuzed to detonate on impact have a lethal blast radius of 177 ft and a lethal fragmentation of 77 ft against aircraft in the open. However, these figures are reduced to 60 ft against aircraft in revetments and a single bomb in one revetment is unlikely to affect an aircraft in an adjoining revetment. The proximity fuzed 1,000lb bomb is likely to provide better fragmentation effect against aircraft including those in revetments.

b. **BL755**. A single BL755 has a kill probability of the order of 80% against parked aircraft. Thus sticks of BL755 provide the maximum response against aircraft parked in revetments or in the open.

c. **Mauser 27 mm Cannon**. The Mauser with a mixture of APHE and HE ammunition should be effective against aircraft in the open.

22.(C) **Installations**. The installations that provide the operational, servicing and administrative support on an airfield may be worthwhile targets: hangars, workshops, fuel and explosive stores, flying control, administrative and domestic buildings. The extent of these facilities will depend on the size and importance of the airfield. For instance, 'hardened' MOBs will have all of these installations whereas some DOBs and grass strips may only have tents, telephones and fuel drums. Wherever they are located, VPs such as fuel and explosive installations are likely to be highly protected, dispersed and camouflages. Surface fuel tanks are normally constructed from steel plate which varies in thickness from $^3/_{16}$ in to $^1/_2$ in, but this would be vulnerable to 27 mm shells. Partially sunken fuel tanks are likely to be covered with concrete slabs, two feet thick, and their destruction would require direct hits from 1,000lb bombs. As explosive stores are likely to be well dispersed and protected in bunkers, only the1,000lb bomb is likely to have the desired effect.

RADAR TARGETS

23.(C) **DMPIs**. Attacks against radar targets should be directed against the control elements. However, if these are hardened, cannot be precisely located, or if effective weapons are not available, the aim should be to destroy the antennae and support facilities.

24.(C) **Target Characteristics**. The characteristic components of an Early Warning or Surveillance Radar site - vans, towers and antennae - are vulnerable to all Tornado weapons. Most radar sites are positioned on high ground or in the open and many have large tall antennae, for example SQUAT EYE, FLAT FACE, LONG TRACK, TIN SHIELD and TALL KING. Since these targets should normally be fairly easy to detect in visual and non-visual conditions, the reduced acquisition problems should enhance the probability of a successful attack.

25.(C) **Choice of Weapons**. The greatest area of effect would be obtained from proximity fuzed bombs; however, these should be used in conjunction with ALARM when the target array is compatible with the seeker head of the missile. Impact-fuzed bombs are the next best choice although BL755s would also be effective, with hits on installations resulting in internal damage from the plasma jet and slug, and the secondary fragmentation effect damaging thin-skinned structures situated near the impact points. With suitable designation LGB could provide a high kill probability (P_k) on these targets. HE 27 mm ammunition would also be effective against electronic installations.

SAM TARGETS

26.(C) **DMPIs.** If ALARM is available, and the frequency of the threat system falls within the frequency coverage of the seeker head, the radar/antennae vehicles are the primary target associated with a SAM site. However, if the site is to be attacked by more conventional weapons, the primary target is the command and control (C^2) element, followed by radar/antennae vehicles, loaded launchers, missile reserves and other support facilities. The missile may not always destroy the system and achieve a "hard" kill. However, if the threat radar has been forced to shut down because of the presence of ALARM, the missile may have been successful in its aim by achieving a "soft' kill.

27.(C) **Fixed SAM Sites.** Permanent surface-to-air missile sites have their missile launchers and associated loaders widely dispersed within the site area. Typical SAM layouts are designated 'star', 'fan' and 'daisy'. The central control facilities are usually contained in vans, some of which may carry radar aerials. The vans and launchers located in the central area are likely to be revetted and bunkered with earth up to about 12 ft in height and width. The fire control centre usually consists of three main components - the radar control van, command control van and the generator, each of which is vital to the operation of the site.

a. **SA-2.** Significant damage to any of the C^2, radar or power distribution components, which are vulnerable to both blast and fragmentation (from CBU, bombs or cannon) can result in the system being inoperative. In addition, the SA-2 is liquid fuelled and vulnerable to perforation by fragments up to a range of 100 ft from a 1,000 lb bomb burst. One technique for successful results would be first to attack the C^2 complex with CBU and having thus reduced the site's ability to guide missiles, then finish the attack with retard bombs.

b. **SA-3.** There are many variations to an SA-3 layout but normally sixteen missiles on four launchers are mounted in the 'ready' position. The LOW BLOW guidance radar is invariably situated on a mound in the centre of the site and provides a vulnerable target. All control vans and components of SA-3 are vulnerable and if damaged would seriously degrade the efficiency of the site.

c. **SA-5.** The SA-5 system is arranged in launch complexes; each complex appears to consist of up to five launch sites. Each launch site contains six single revetted launchers arranged in an oval pattern. One SQUARE PAIR fire control radar is provided for each launch site, displaced from the launchers by about 3,000 ft. Acquisition and height finding radars, typically BACK NET or TALL KING and SIDE NET or ODD PAIR respectively, are normally located in a separate area about 3 nms from the launch complex. The missile is semi-active and, therefore, destruction of the fire control radars or the radar antenna would render the site inoperative. Blast and fragmentation weapons should be effective.

d. **SA-10a.** Prepared sites are required for SA-10a. Although specially built sites have been observed, modified SA-2 and SA-3 sites are also in use. The system is capable of rapid deployment to pre-surveyed sites; therefore, rapid wartime relocation is feasible. Originally each site contained six launchers in revetments with a central guidance area for the FLAP LID, and CLAM SHELL located adjacent to each site. BIG BIRD is the general surveillance radar. Some sites appear to have 12 launchers. All blast and fragmentation weapons should be effective against the fire control radars.

27.(C) **Mobile SAMs**. SA-6, SA-8 and SA-9/13 are to be found deployed in many different countries around the world together with their 'blue' equivalents eg Roland, Hawk. In addition, S-10b, SA-11 and SA-12 are deployed in some states of the CIS. Most mobile SAMs are organised into battalions, each with a number of batteries, which form fire units comprising, where applicable, Target Acquisition Radars (TAR), Target Tracking Radars (TTR) and TELs. Not only are radar antennae vulnerable to ALARM, within the caveat of para 26, but all of these components are also vulnerable up to a radius of 100 feet from a 1,000 lb bomb attack. Furthermore, the complete systems, including radars and control vans, are vulnerable to all Tornado fragmentation weapons. The CBU is therefore a particularly useful weapon against the mobile missile systems. Likewise, if target acquisition can be assured, 27 mm HE/APHE ammunition should be effective against mobile SAMs.

AI TARGETS

Most

28.(C) ~~The majority of AI~~ targets will be mobile and, therefore, time sensitive. During temporary static phases, typical targets will employ camouflage and dispersal techniques to help increase their survivability. Fixed targets such as bridges, railway yards, headquarters and depots may be specified within a pre-planned programme.

MOBILE TARGETS

29.(R) Mobile targets can include mobile bridging equipment, armour, soft skinned vehicles, mobile SAMs, AAA, trains and even troops. When mobile, most of these would be targets-of-opportunity and Tornado is unlikely to be tasked specifically against them as AI missions. The exception could be bridging operations where mobile equipments could have become comparatively static within one target area.

30.(R) **Bridging Equipment**. Non-amphibious artillery and logistic vehicles require a variety of bridging equipment. As the advance progresses, the frontline assault bridges are replaced with a variety of fixed and floating bridges, designed primarily for rear area use, which will allow supporting traffic to keep pace with the general advance. Bridging reconnaissance, construction or movement could take place both by day and night anywhere beyond the FEBA. Whenever possible, pontoon bridging is positioned under the cover of darkness to permit traffic to flow prior to daybreak. A complete emplacement operation, possibly with the aid of a helicopter assault group, might be completed within three hours.

31.(C) **Choice of Weapons**. Bridging is more vulnerable to the 1,000 lb bomb than to other weapons carried by Tornado. Due to the relative incompressibility of water, the impulse created underwater is up to 30 times as great as the impulse created in air. A delay fuze is required to create an underwater explosion. 1,000 lb retard bombs released from level flight could ricochet off water; a dive angle of 5° or greater might assist in reducing this problem. (See Figure 5-2-2).

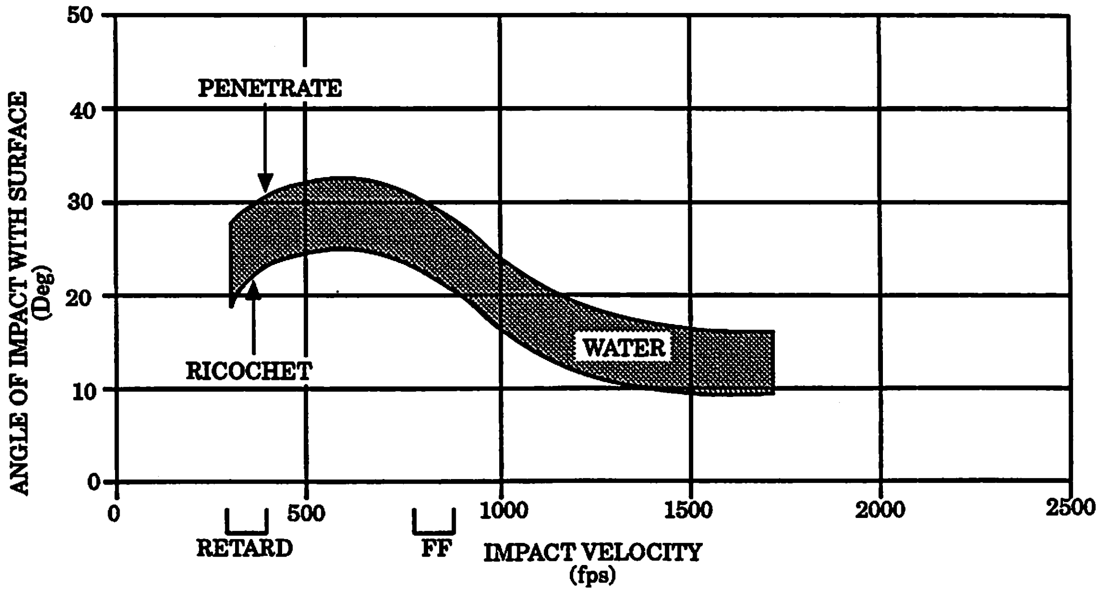


Figure 5-2-2(C) - Ricochet Conditions off Water

As bridging is only likely to be attempted over relatively shallow stretches of water, the ideal depth for an underwater explosion may not be achieved and a reduced effect must be accepted. A pontoon type of bridge, similar to a Gillois or M-2 bridge measuring approximately 13.5 ft wide and 400 ft long when deployed, has an effective vulnerable width of 60 ft. Direct hits would destroy most temporary bridges whilst a near miss on most of the lighter bridging equipment would result in damage varying from over-turning to severe buckling, thus denying use of the crossing for a limited period. The heavier multiple-type of pontoon bridge could probably be made operational again within an hour by floating in a replacement section. Temporary bridging is generally not suited to attacks with LGBs (particularly from low level) as it usually has little vertical extent and specular reflections off adjacent water will decrease the available energy on which the LGB can home. Furthermore, the laser spot size could exceed the width of the bridge if the bridge is small.

FIXED TARGETS

32.(R) **Permanent Bridging.** JP233 could be used to disrupt movement of armour for short periods by denying access to the approaches of a bridge. ~~but is unlikely to be released for such a task~~. The components of a permanent bridge most responsive to direct hits from bombs are the piers and abutments; hits against road approaches or the crown of the bridge would be relatively easy to repair especially since the span is unlikely to have dropped. Only very large permanent bridges are likely to be hit by unguided 1,000 lb bombs and to undermine piers and abutments effectively deep penetration of the construction would be necessary, thus requiring a delay fuze and a high impact velocity. The bomb impact angle and the use of delay fuzes may result in bombs ricocheting before detonation. Although a retard bomb attack at low level would result in a

AL2 (M3)

higher probability of a direct hit, the degree of penetration would be negligible. The optimum weapon for attacks against large permanent bridges is the LGB as demonstrated by the often spectacular results achieved from medium altitudes during Operation GRANBY. However, selection of a suitable aiming point was not always easy. Simply constructed decking bridges presented no problems and striking the abutments produced good results, and provided the enemy with the most difficult quick reconstruction task. Other bridges presented dilemmas: bombing the abutments sometimes resulted in little damage whereas subsequent attacks on the spans produced gratifying results - ideally the exact construction of a bridge needs to be known! If LGBs are not available, a 4/5 bomb Mini-Loft attack in Salvo executed from a well chosen attack direction might be successful, especially since some aiming error would be compensated for by the vertical extent of the target and the lateral separation of bombs that occurs when released as pairs. The effect of near instantaneous multiple impacts - 'the synergistic effect' - has yet to be analysed but penetration is possible at striking angles of between 65° and 79° to the horizontal with impact velocities of between 500 and 850 ft.sec^{-1} although reinforced concrete structures will reduce the penetration (See Figures 5-2-1 and 5-2-2).

33.(R) **Railway Yards.** Although JP233 provides the best capability against railway yards, it is unlikely to be made available for this task. Therefore, 1,000 lb bombs delivered either in the FF or retard modes are likely to be the first option against railway yards. Maximum damage to railway tracks should be achieved by the cratering effect of the 1,000 lb bomb/short delay fuze combination. If rolling stock is the target instantaneous fuzes should be chosen. Rolling stock should also be vulnerable to the effects of CBUs and 27 mm HE/APHE ammunition.

34.(C) **Headquarters / Depots.** Wartime Field Headquarters, Emergency Deployment Areas (EDA), Storage Sites and Depots are likely to exist already and many would be concealed in forests. Field Headquarters or Command Posts are likely to be housed in bunkers, either log revetted or concreted, and they could be semi-submerged. EDAs vary in size with between 10 and several hundred vehicle pits. Forest cover would have a detrimental effect on the performance of impact weapons such as 1,000 lb bombs and BL755. However, 1,000 lb bombs or LGBs with delayed fuzes should be the best option against the bunkers although the choice of attack headings would be critical. Against vehicles dispersed in woodland 1,000 lb proximity fuzed bombs should be a better option than BL755. Impact fuzed retard 1,000 lb bombs should be used to destroy surface POL and ammunition storage sites, whereas FF bombs with delayed fuzes should be used against sub-surface sites. Experience during Operation GRANBY showed that surface oil storage tanks were not ideal targets for LGBs as the large amount of smoke from a tank hit by the first weapon(s) obscured the laser guidance for subsequent attacks.

BAI TARGETS

ARMOUR

35.(R) Arguably, the most effective way of disrupting enemy battle groups in the vicinity of the FEBA is to neutralise their tanks and APCs. Armour will also be found further behind the frontline, in large groups and in non-tactical dispositions. As many tanks are likely to be fitted with mine-clearing rollers, bulldozing equipment or ploughs, consideration should be given to attacking these specially fitted tanks with the intention of reducing the overall efficiency of the armoured formations. There will be as many APCs as tanks in the forward battle area and these vehicles would also be attractive targets. APCs are frequently used for the forward supply of ammunition and fuel, and the importance of APCs as battlefield targets should not be underestimated. Modern ex-Soviet battle-tank armour normally exceeds 450 mm in thickness, primarily distributed to protect vulnerable areas from attack from the front. Thinner plate is normally found on the sides, rear and on the engine decking. Light amphibious AFVs used for reconnaissance and artillery support have an armour thickness of 18 mm and utilise a light chassis, eg the ZSU-23-4, BMD and PT76; they are vulnerable to all Tornado fragmentation weapons. Track gear, suspension, IR illuminators, snorkel equipment and auxiliary fuel tanks are exposed and are more vulnerable to all weapons strikes than the main hull surfaces. The best direction for attacking an AFV is therefore from the rear quarter, regardless of weapon employed.

36.(C) **1,000 lb Bomb.** A direct hit from a 1,000 lb bomb will result in a tank kill whereas an impact within 14 ft of the tank should result in at least a category 'M' kill (mobility, not repairable in the field). However, the kill probabilities are not high when operational aiming errors are considered! Concentrations of tanks, light tanks and APCs found on the battlefield or at choke point such as bridge crossings, will be more vulnerable to both retard and FF 1,000 lb bombs than individual heavily-armoured tanks.

37.(C) **BL755.** The BL755 is fitted with a hollow charge warhead and was designed to defeat the relatively thin armour on the top surfaces of the Soviet MBT. Bomblets which defeat a tank's upper armour and hit either fuel or ammunition are likely to achieve a 'K' kill (immobilized beyond repair) whereas a slug that enters the crew compartment may only achieve a 40% 'F' kill (firepower, crew or gun) - the probability of 'F' kill is determined by the amount of spall created, which in turn is inversely proportional to the thickness of armour penetrated. APCs and lightly armoured support vehicles are particularly vulnerable to the damage mechanism of BL755 for all categories of kill.

38.(R) **27 mm Cannon.** Medium and light tanks may be vulnerable to 27 mm cannon shells especially with hits on rear decking, fuel tanks and running gear. Other types of armoured vehicles should be vulnerable to attack using either HE or APHE 27 mm ammunition.

TROOPS

34.(C) The 1,000 lb bomb is calculated to have an MAE of 7,100 sq ft for a ground burst against troops in foxholes or trenches, whereas the proximity fuzed 1,000 lb bomb airburst (nominal 6 m AGL burst height) will only increase the MAE to 10,900 sq ft (see Table 5-2-2 which is extracted from the CWEM). The cluster weapon, with an average MAE of 50,000 sq ft, would not be defeated easily by undulating terrain and may prove to be the best weapon to use against troops.

TARGETS OF OPPORTUNITY (TOO)

40.(R) It is unlikely that prime weapons will be available for TOO since they should be or should have been expended on the tasked target. Thus for TOO attacks, Tornado will probably only be armed with 27 mm cannon. Typical TOO targets are likely to be mobile and therefore similar to some AI and most BAI targets.

MISSILES/ARTILLERY

41.(R) SAMs, Surface-to-Surface Missiles (SSM) and Artillery would be vulnerable to cannon fire. Nuclear capable SSMs or artillery would provide very significant targets.

Serial No (a)	Type of Fuze (b)	MAE (sq ft) (c)	Position (d)
1	Instantaneous	35,000	Men standing. Rolling ground
2	Prox (6mAGL)	45,200	Men standing. Rolling ground
3	Instantaneous	16,400	Men prone. Rolling ground
4	Instantaneous	7,100	Men in foxholes/trenches
5	Prox (6mAGL)	10,900	Men in foxholes/trenches

Note: MAE assumes 30° bomb impact angle.

Table 5-2-2(C) - MAE of 1000lb Bomb Against Troops

AAA

42.(R) In a AAA battery, the director radar and guns are sensitive to blast and fragmentation from HE/APHE ammunition. Gun crews and gun fire control facilities are equally susceptible to these effects. Kill probabilities will depend on the particular layout and location of the battery.

HELICOPTERS

43.(R) It is anticipated that helicopters would support bridging operations and general troop assaults in the FEBA and, at times, operations up to 50 km behind our own lines. Visual acquisition of small helicopters can be difficult, but rotor glint, helicopter size (eg HOOK and HIP) and the numbers involved in an assault would make the acquisition problem less acute. Helicopters are extremely vulnerable to most Tornado weapons when stationary and to cannon fire (and Sidewinder) when airborne. Helicopters are also susceptible to aircraft wake turbulence; a helicopter caught in jet wash and wing vortices close to the ground could be seriously jeopardised.

SUMMARY

44.(R) The table at Annex A summarises the optimum Tornado weapons-to-target matching. It has been derived after considering target response and delivery accuracy (as far as is presently known) and takes into account aircraft vulnerability to target defences during the delivery profile.

INTENTIONALLY BLANK

WEAPON-TO-TARGET MATCHING GUIDE

TARGET		CHOICE OF WEAPON		
		1st	2nd	3rd
RUNWAY		JP233	LGB	GPB-FF
HAS-PBF		LGB	GPB-FF	GPB-RET
AIRCRAFT IN OPEN		CBU	GPB-FF (AB)	GPB-RET/CANNON
POL/AMMUNITION-ON SURFACE		GPB-FF	GPB-RET	CBU
POL/AMMUNITION-SUB-SURFACE		LGB	GPB-FF	
RADAR		ALARM (1) (3)	GPB-FF	CBU/CANNON
SAM	FIXED	ALARM (1) (3)	GPB-FF (AB)	CBU/GPB-RET
	MOBILE	ALARM (1) (3)	CBU	CANNON
AAA		CBU (1)	GPB-RET (AB) GPB-FF (AB)	CANNON
BRIDGING EQUIPMENT		GPB-RET	CBU	CANNON
PERMANENT BRIDGES		LGB	GPB-FF	GPB-RET
ROADS (CHOKE POINTS)		JP 233 (2)	GPB-RET	GPB-FF
RAILWAY YARDS		JP 233 (2)	GPB-FF	GPB-RET
HQ/DEPOTS		LGB	GPB-RET	GPB-FF
ARMOUR		CBU	CANNON	GPB-RET
PERSONNEL		GPB-FF (AB)	CBU	GPB-RET

Notes:

(1) ALARM is more likely to achieve a 'soft' kill, ie suppression of the victim radars to cover an attack wave.

(2) But unlikely to be allocated to such tasks.

(3) Hard Kills will only be possible if the radar frequency is within the coverage of the seeker head.

(4) **Abbreviations** AB Airburst FF Freefall RET retard
GPB General Purpose Bomb eg, 1000 lb HE (MC)

INTENTIONALLY BLANK

JP233 EJECTION TIMING PER CRATERING MUNITION (FOR EACH DISPENSER)

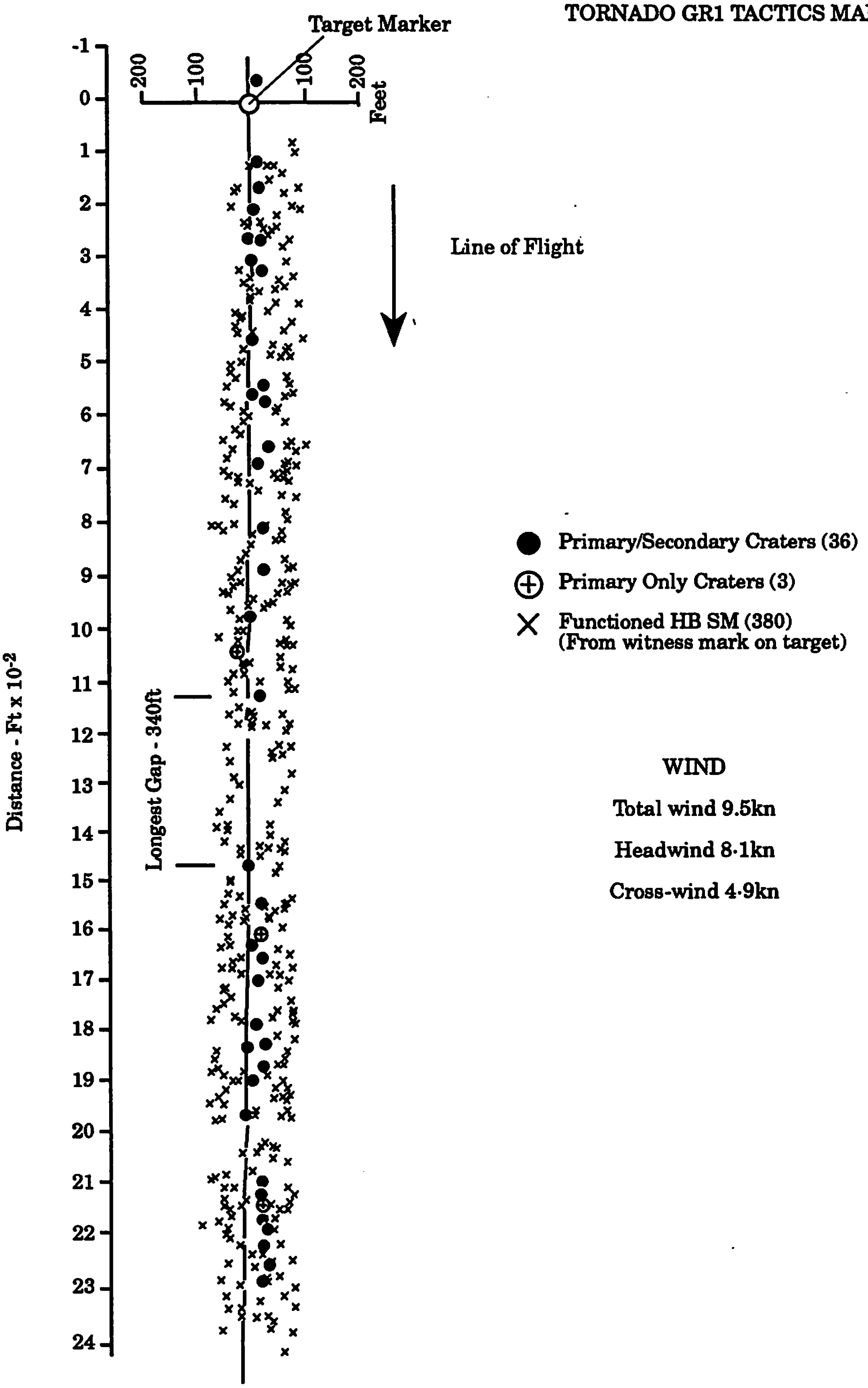
Speed Band Setting	Long Stick Time (msec)	Short Stick Time (msec)
450	380.80 (1)	95.20 (2)
500	342.40	85.60
550	311.68	77.92

Notes

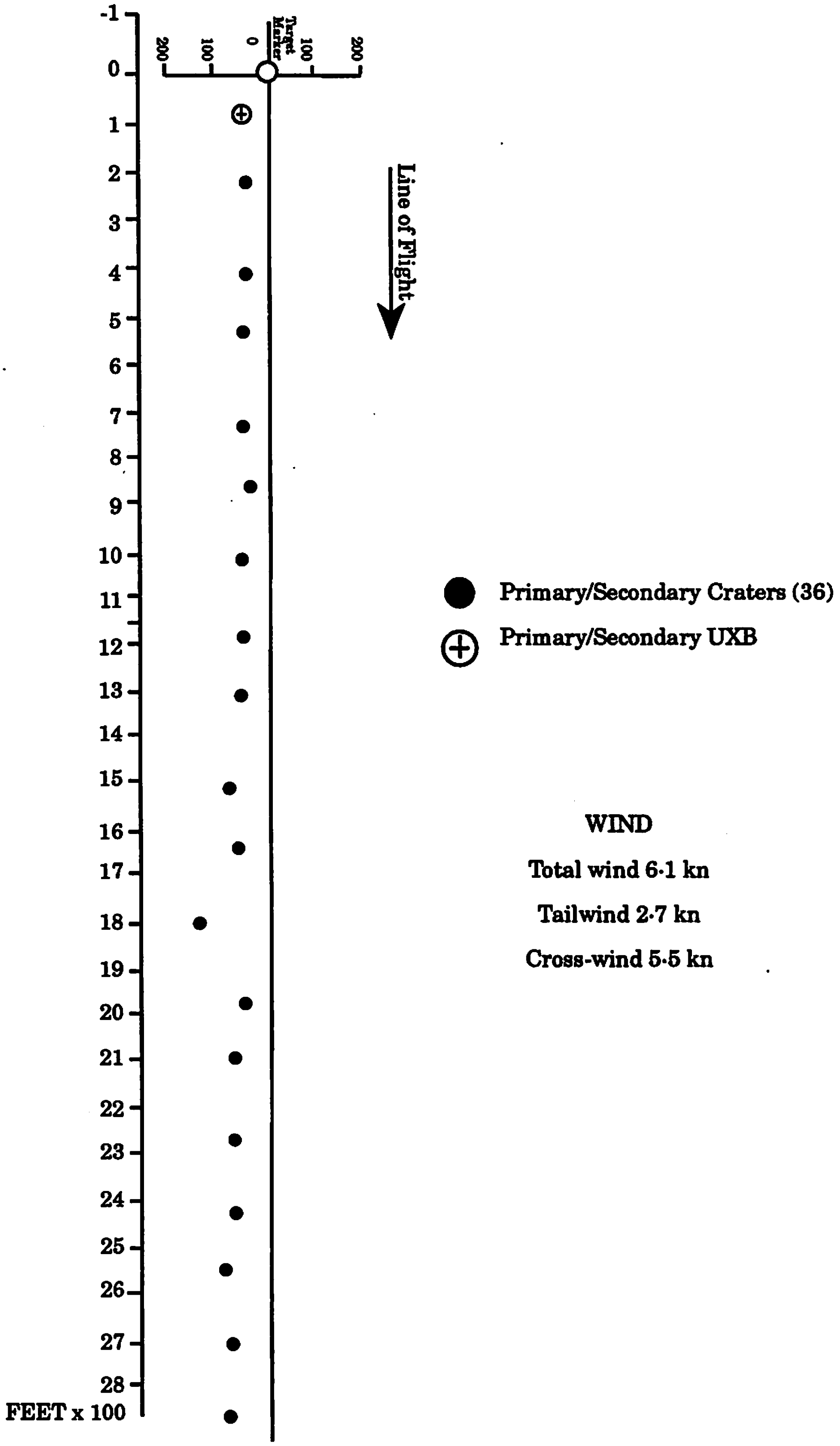
(1) Equates to long stick delivery being completed in 11.4s.

(2) Equates to short stick delivery being completed in 2.9s.

INTENTIONALLY BLANK



JP233 - RESULTS FROM TYNE 4 - SHORT STICK COMBINED SG/HB SM PATTERN



WIND

Total wind 6·1 kn

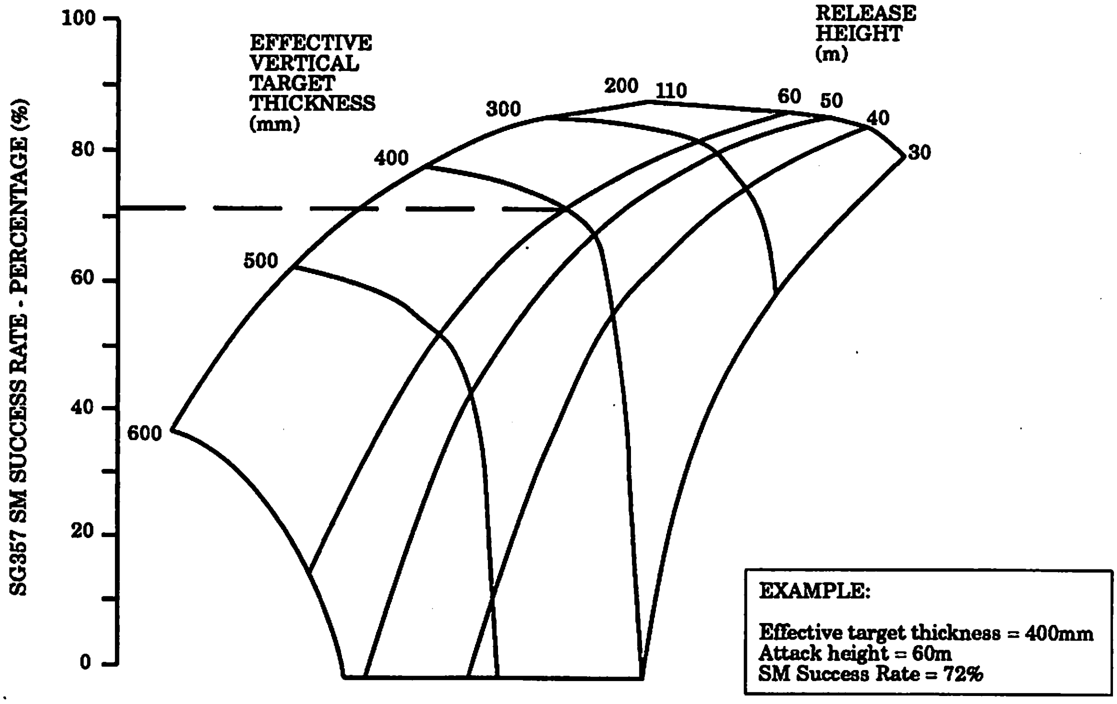
Tailwind 2·7 kn

Cross-wind 5·5 kn

RESULTS FROM TYNE 4 - LONG STICK SG PATTERN

ANNEX D TO
SECTION 5, CHAPTER 2 OF
TORNADO GR1 TACTICS MANUAL

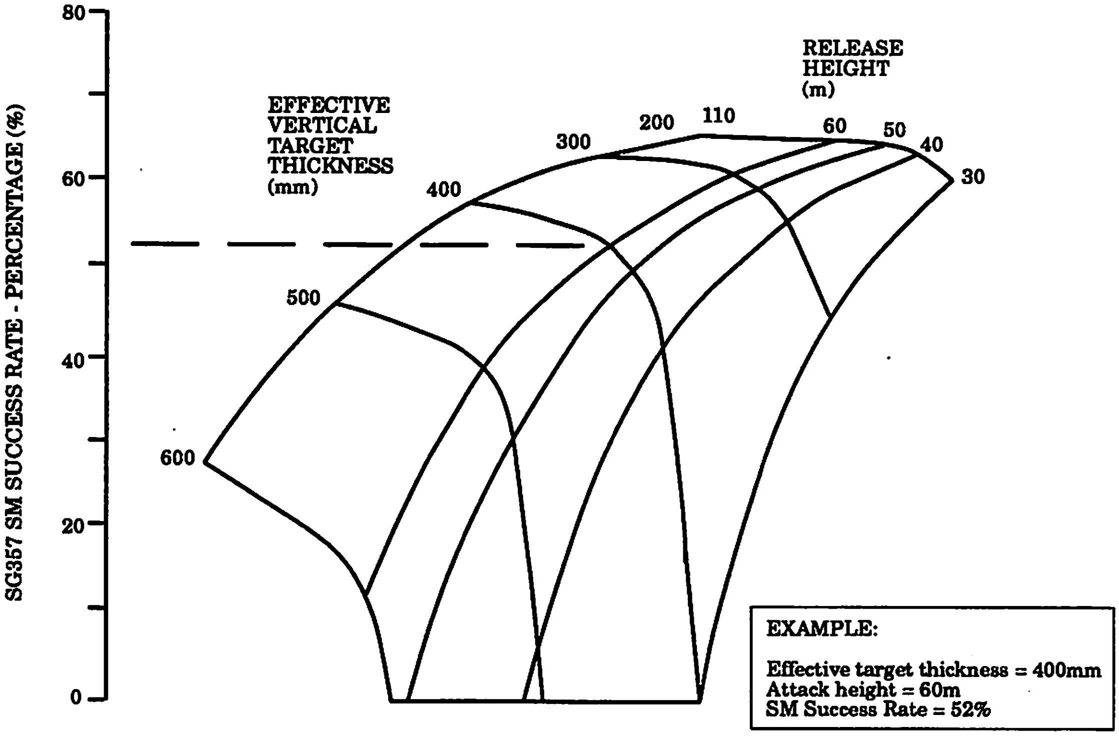
JP 233 RUNWAY CRATERING SM SUCCESS RATES



EXAMPLE:

Effective target thickness = 400mm
Attack height = 60m
SM Success Rate = 72%

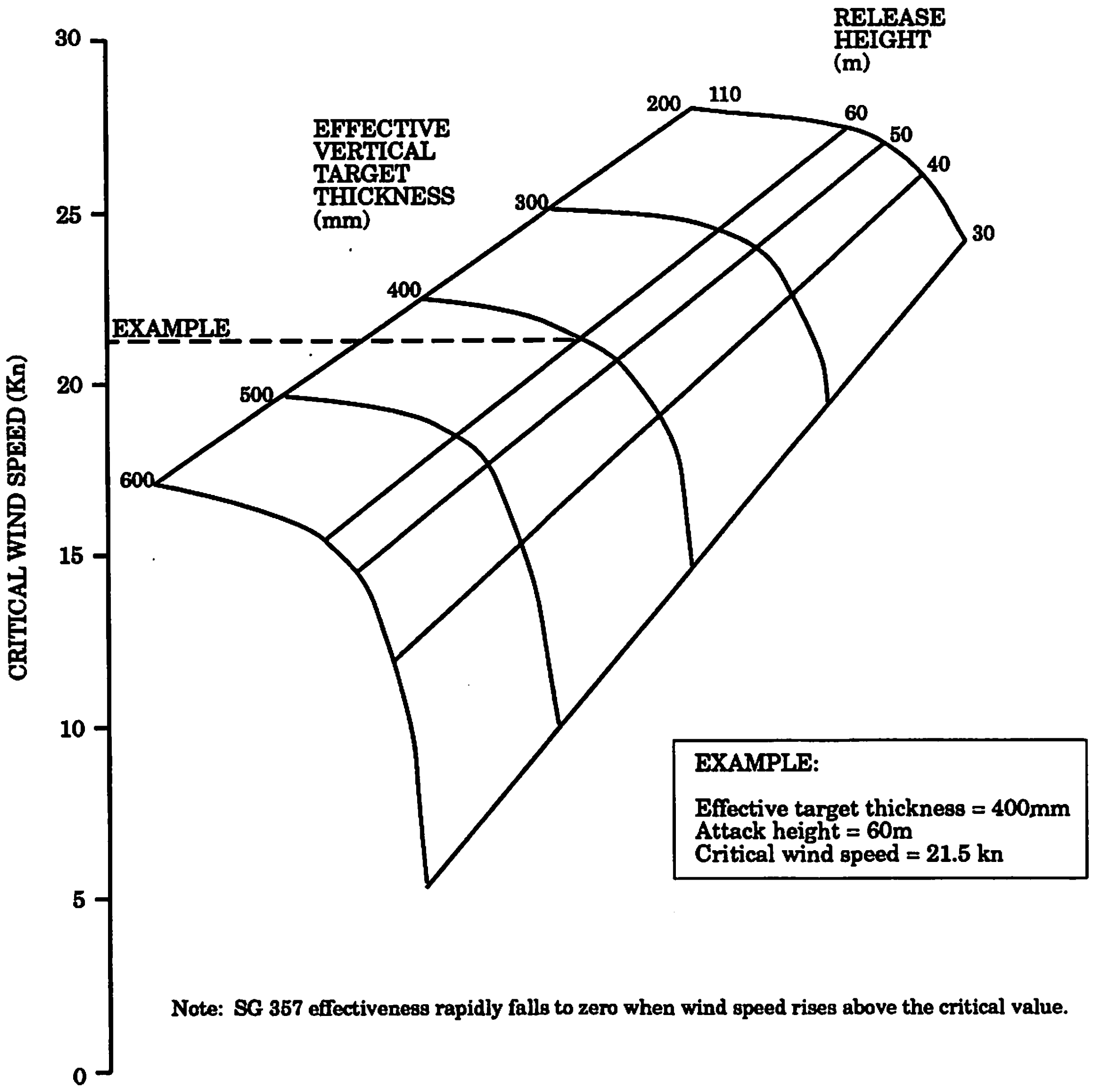
Figure 5-2D-1(C) - Long Stick Attacks



EXAMPLE:

Effective target thickness = 400mm
Attack height = 60m
SM Success Rate = 52%

Figure 5-2D-2(C) - Short Stick Attacks



EXAMPLE:

Effective target thickness = 400mm
Attack height = 60m
Critical wind speed = 21.5 kn

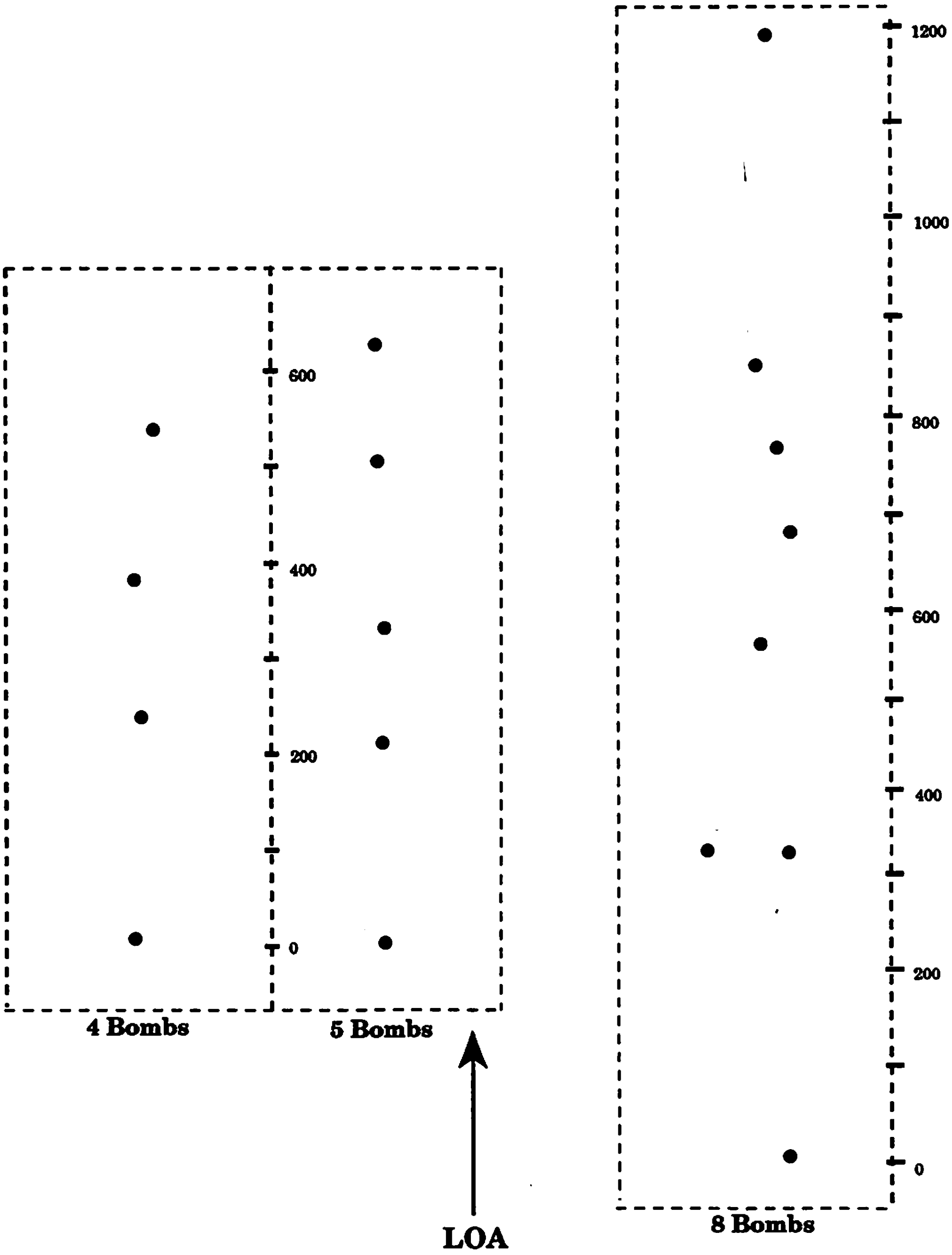
Note: SG 357 effectiveness rapidly falls to zero when wind speed rises above the critical value.

Figure 5-2D-3(C) - Variation of Critical Wind Speed with Target Thickness

TYPICAL 1000lb BOMB STICK PATTERNS

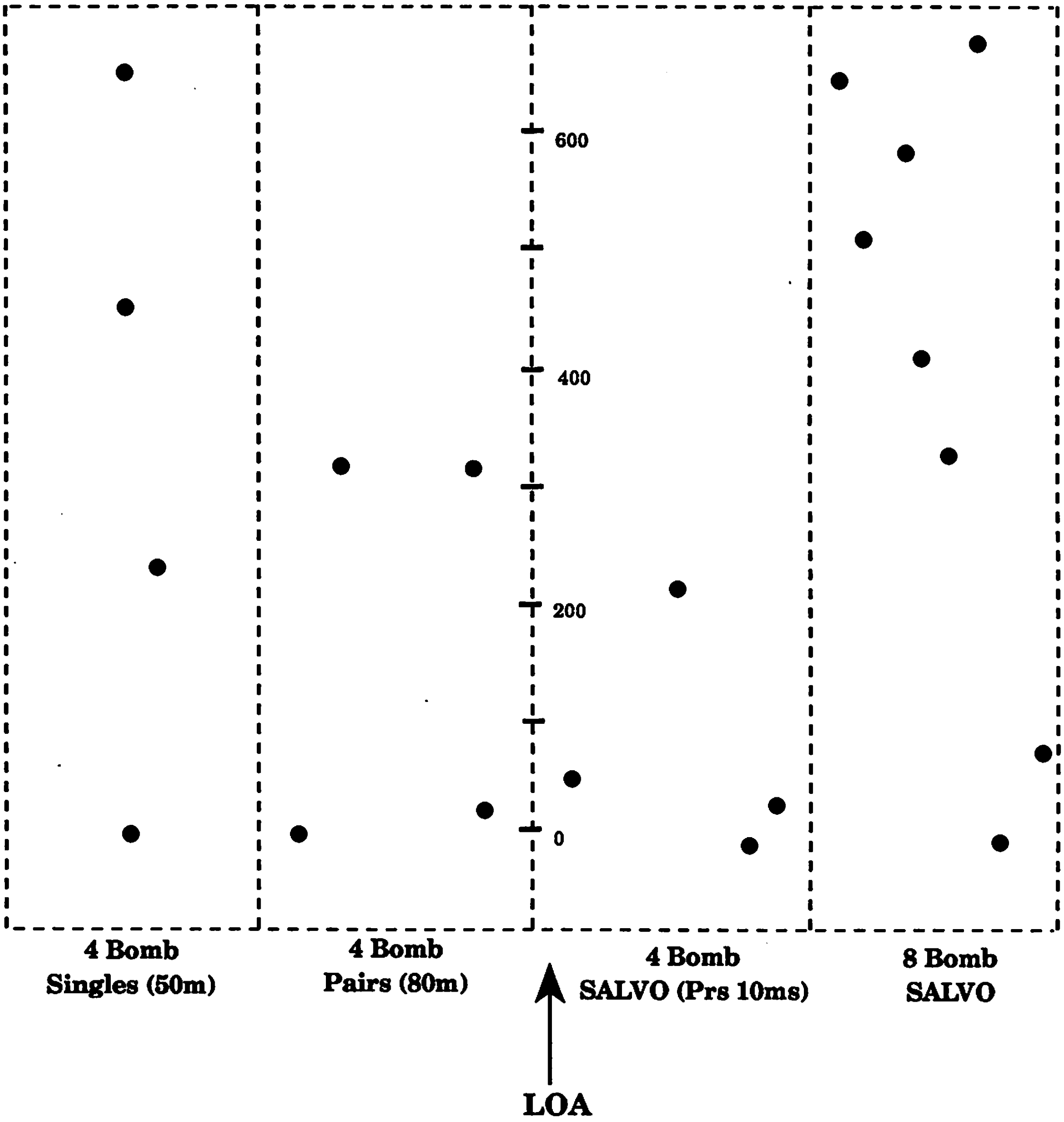
1.(C) **Retard Bomb Pattern.** The release parameters for the retard bomb were:

	Speed (Kn)	Height (ft)	Release Sequence
4 Bombs	490	200 Level	Singles at 200 m.sec
5 Bombs	540	200 Level	Singles at 160 m.sec
8 Bombs	550	200 Level	Singles at 160 m.sec



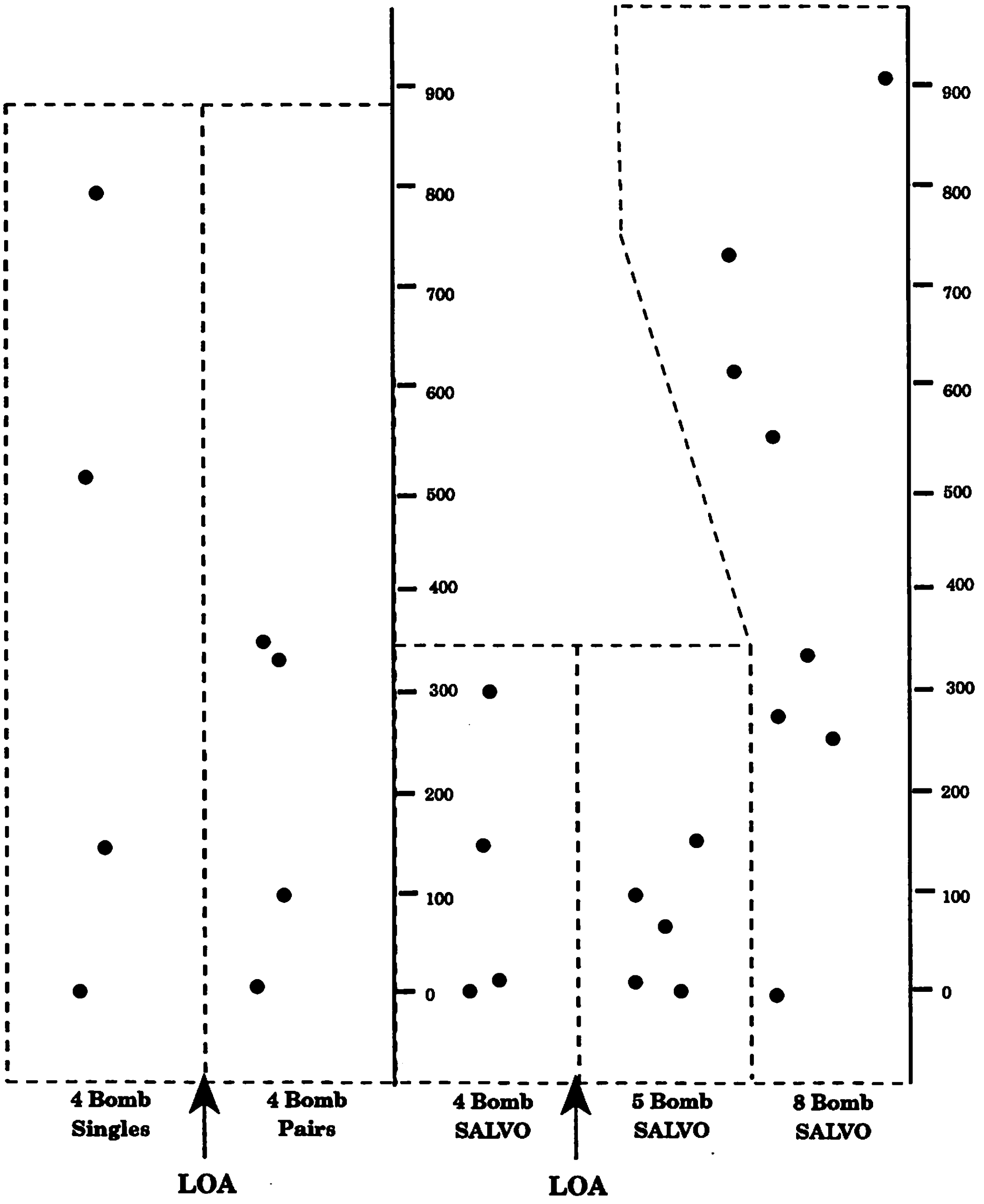
2.(C) **Low Loft Patterns.** The parameters for the Low Loft releases were:

	Speed (Kn)	Climb Angle	Release Sequence
4 Bombs	540	30°	Singles at 50 m
4 Bombs	540	30°	Pairs at 80 m
4 Bombs	540	30°	Salvo (Pairs at 10 m.sec
8 Bombs	540	30°	Salvo



3.(C) **Mini-Loft Pattern.** The parameters for the Mini-Loft releases were:

	Speed (Kn)	Climb Angle	Release Sequence
4 Bombs	525	8°	Singles at 40 m
4 Bombs	525	8°	Pairs at 40 m
4 Bombs	550	8°	Salvo (Pairs at 10 m.sec
5 Bombs	550	8°	Salvo
8 Bombs	500	8°	Salvo



INTENTIONALLY BLANK

MFBF FUZING INFORMATION

FUZE SETTING IN MILLISEC FOR DIFFERENT DELIVERIES

TARGET TYPE	Laydown	Dive Angle				Toss/ Loft	Medium Altitude
		5°	20°	30°	45°		
HAS (3)	Inst or 20 (4)	Inst or 20 (4)	Inst or 20 (4)	Inst or 20 (4)	20	Inst or 20 (4)	20 (1) Inst (2)
PBF (3)	10	10	10	6.25	6.25	6.25	20 (1) Inst (2)
RUNWAY	0	0	0	0	50	0	50 (1) 0 (2)
STEEL/WOOD HANGAR	10	10	10	10	10	10	10
Single STOREY FACTORY (Thin-roof)	0	0	0	0	0	0	0
FACTORY	10	10	10	10	10	10	10
MULTI-STOREY BUILDING	20	20	20	20	20	20	20
BRIDGE (3)	0	0	0	6.25 (5)	6.25 (5)	6.25 (5)	6.25 (5)
POL-SURFACE	0	0	0	0	0	0	0
POL-BURIED	20	20	20	20	20	20	20
POL-STORAGE TANKS	0	0	0	0	0	0	0
RADARS	O/AB	O/AB	O/AB	O/AB	O/AB	O/AB	O/AB
SAMs	O/AB	O/AB	O/AB	O/AB	O/AB	O/AB	O/AB
FPBs	AB	AB	AB	AB or 10	AB or 10	AB	AB or 10
ARTILLERY/ SSM	0/AB	O/AB	O/AB	O/AB	O/AB	O/AB	O/AB
PERSONNEL	AB	AB	AB	AB	AB	AB	AB

AB = Airburst

See overleaf for Notes

Notes:

1. Altitude at or above 15,000 ft.

2. Altitude below 15,000 ft.

3. When attacking hard targets (eg a HAS, PBF, bunker or bridge piers/abutments) a direct hit, or in some cases a near miss, is required to achieve a 'kill'. If LGBs are not available a very large OTR is likely to be needed to neutralise the target and therefore consideration should be given to changing the aim of the mission to harassment. To achieve successful harassment consider using a variety of long delay settings within each stick. However, the EOD capability of the enemy must be considered prior to employment. If the enemy is prepared to sacrifice the lives of personnel or hostages the tactic will probably be of little value.

4. For attacks with low impact angles and impact velocities, there is a high probability of ricochets against hard surfaces. Against runways use an instantaneous setting unless using dive angles in excess of 45° or level delivery from above 15,000 ft. Fuze delays are for HAS/PBF with a covering of 10 ft of earth/sand; for uncovered HAS/PBF use instantaneous fuze setting for 4 laydown, loft and dive deliveries below 30° or level deliveries from below 15,000 ft.

5. If DMPI is bridge decking use instantaneous because of targeting constraints. Best weapon effects against abutments.

ANNEX G TO
SECTION 5, CHAPTER 2 OF
TORNADO GR1 TACTICS MANUAL

MINIMUM REQUIRED TAKE-OFF SURFACES FOR EX-SOVIET FIGHTER TYPE AIRCRAFT

Aircraft			**MOS (ft)** See Notes(2) (3) (4)	
Designation	NATO Code-name		Emergency	Full
MiG 15	Fagot		1600	2100
MiG 17	Fresco:	A/B/E	2000	2700
		C/D	1200	1800
MiG 19	Farmer		1700	2500
MiG 21	Fishbed:	C/E	3800	4900
		D/F	2100	3000
		H	3000	4100
		J/K/L/N	2300	3500
MiG 23	Flogger	B/C/E/F	1600	2800
MiG 25	Foxbat:	A	3600	5200
		B/C/D	3600	5800
MiG 27	Flogger	D	2000	3900
MiG 29	Fulcrum		1300	1900
MiG 31	Foxhound		4200	4700
Su 7	Fitter A		3400	5200
Su 9/Su 11	Fishpot B/C		2100	2600
Su 15	Flagon:	A/C/D	3100	3600
		E/F/G	2500	3100
Su 17	Fitter:	B	2600	4000
		C/E/G	2200	3600
		D/H	2300	4200
Su 24	Fencer		1900	3400
Su 25	Frogfoot		1500	2100
Su 27	Flanker		1000	1600
Tu 28	Fiddler		4000	4500
Yak 28	Firebar		2800	3200
Yak 36	Forger		VTOL	VTOL

See Notes overleaf

Notes:

1. Minimum clearance width for ALL aircraft is 40ft.

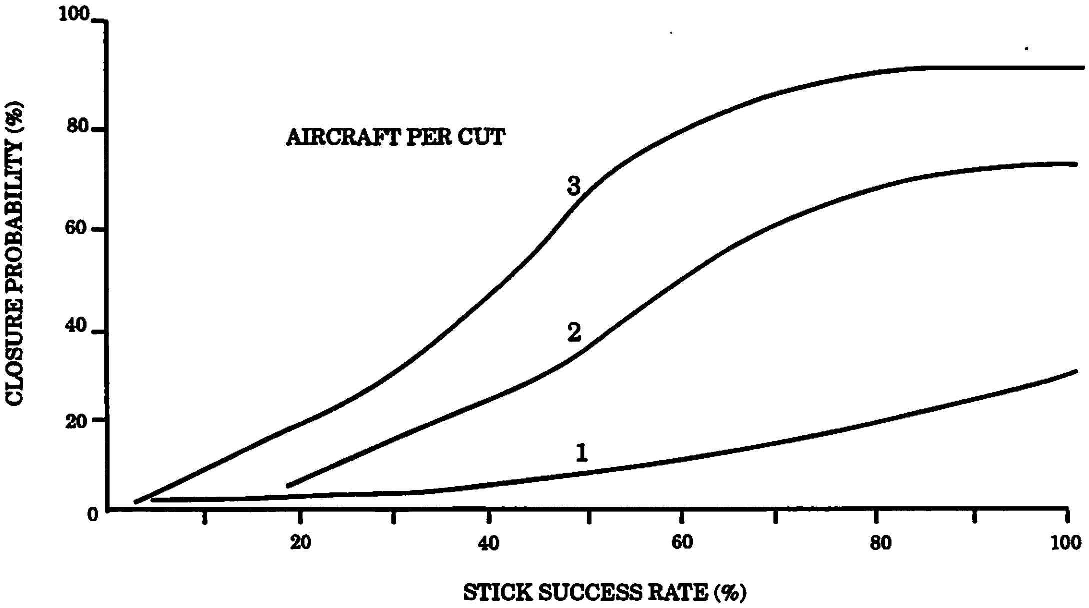
2. Range of values reflects different gross weights for a range of operational configurations. ('Guns only' (emergency) to maximum take-off weight (full)).

3. Whilst it may seem expedient to use the average of the two figures given for minimum clear length (MCL), users should bear in mind that the lower figure although pessimistic is nevertheless a comprehensive denial of the runway to the enemy aircraft.

4. MOS estimates assume ISA conditions and a runway at mean sea level.

ANNEX H TO
SECTION 5, CHAPTER 2 OF
TORNADO GR1 TACTICS MANUAL

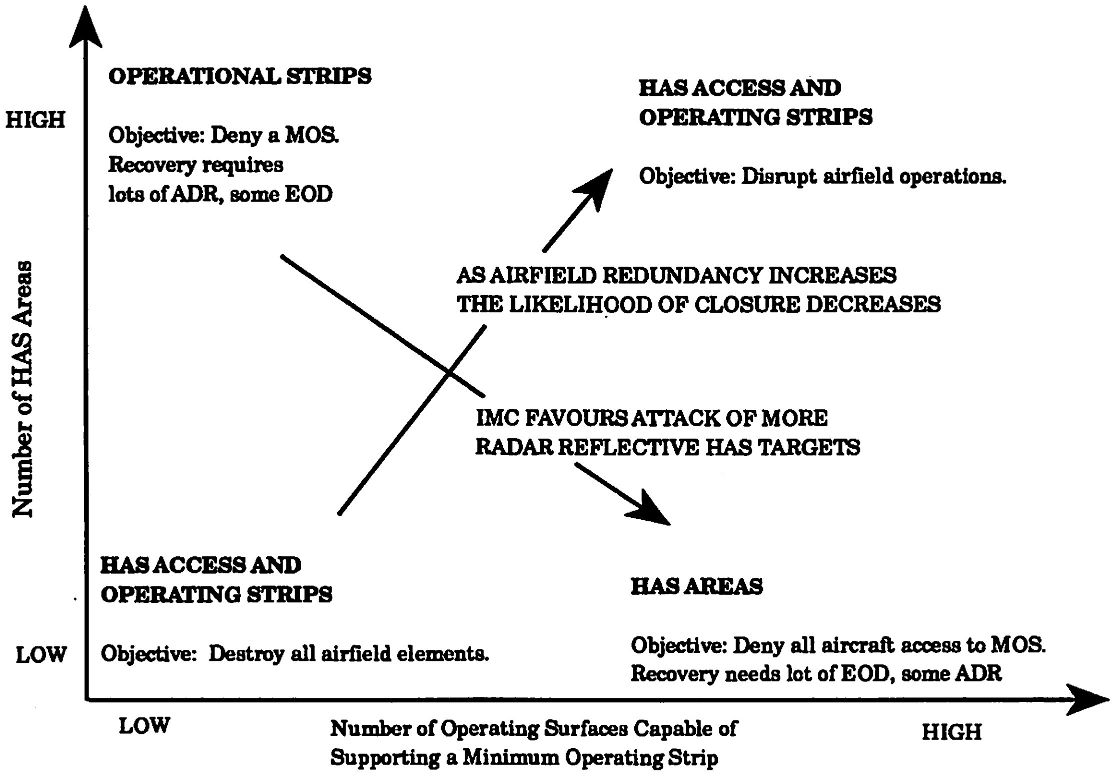
PROBABILITY OF CUTTING RUNWAY WITH ACROSS ATTACK



INTENTIONALLY BLANK

ANNEX I TO
SECTION 5, CHAPTER 2 OF
TORNADO GR1 TACTICS MANUAL

A GUIDE TO JP233 TARGETING OF AIRFIELDS


OPERATIONAL STRIPS
Objective: Deny a MOS. Recovery requires lots of ADR, some EOD
HAS ACCESS AND OPERATING STRIPS
Objective: Disrupt airfield operations.
HIGH
Number of HAS Areas
AS AIRFIELD REDUNDANCY INCREASES THE LIKELIHOOD OF CLOSURE DECREASES
IMC FAVOURS ATTACK OF MORE RADAR REFLECTIVE HAS TARGETS
HAS ACCESS AND OPERATING STRIPS
Objective: Destroy all airfield elements.
HAS AREAS
Objective: Deny all aircraft access to MOS. Recovery needs lot of EOD, some ADR
LOW
LOW
Number of Operating Surfaces Capable of Supporting a Minimum Operating Strip
HIGH

JP233 ATTACK PLANNING CONSIDERATIONS

Serial	Attack Type	COMMENTS
1	Long Stick Attacks Down Runways	a. A reasonable success rate is likely to be achieved in both IMC and VMC (60% and 80% respectively achieved in trials. Early radar bloom increases success rate. b. If successful, much EOD/ADR work will be required to achieve an operating strip. Without an indigenous ADR capability an airfield may be disrupted for several days. c. Line errors may result in a stick missing the runway. In IMC especially this may result in a MOS remaining. Attacks with line errors can however destroy landing/ navigation aids greatly hindering night operations.

Serial	Attack Type	COMMENTS
2	Long Stick Attacks Down Taxiways	a. The success rate is likely to be low in VMC and lower still IMC (23% in trials). This is due to problems with acquisition and targeting of the narrow taxiways. b. Comments 1b and 1c apply, narrower taxiways reduce success rate.
3	Attacks across Runways/Taxi ways	a. Only a small percentage of the munitions actually hit the operating surfaces. The EOD/ADR problem is therefore significantly reduced. b. Across runway/taxiway attacks are likely to degrade operations less effectively than along runway attacks (ORB Memo 2/89). They are also sensitive to aircraft delivery errors and "no shows". c. Line errors may be large because of the lack of distinguishing features along the length of runways/taxiways. This is true for IMC and VMC.
4	Short Stick Attacks around HAS Areas	a. This is a robust method of denying aircraft MOS access. b. Significant EOD problems exist until HB876 and dud SG357 munitions are cleared. c. After 12 hours (when all munitions should have timed out) the residual ADR problem may be small, since it may be possible to taxi around the craters.
5	Peripheral Damage to Logistics Areas	a. There are advantages in ending a stick in a logistics or support area. For example HB876 mines might not damage the revetments of a weapons store but they probably will stop easy movement of weapons and personnel.

AL 2 (MS)

CHAPTER 3 - AIRCRAFT PERFORMANCE

INTRODUCTION

1.(R) The aim of this section is to outline areas where Tornado performance affects operational tasks. Detailed information should be obtained from the ODM.

PERFORMANCE DATA

2.(C) **Use of the ODM.** The Tornado ODM is issued as AP 101B-4101-16-1. For Mk101 engined Tornados the Advanced Issue dated Jun 80 should be used and for Mk103 engined aircraft the 1st Edition dated Dec 87. From the best available information it can be assumed that, with two exceptions, both volumes provide accurate planning data. The exceptions, proved on Trial NONIYS, were that the ODM was optimistic for the distance/time to achieve a given altitude and, more importantly, that it was very optimistic over performance data to cover the 8 bomb, conventional attack configuration. Indeed on Trial NONIYS, this configuration (including 2250 litre UWT) had a calculated DI of 134 but the aircraft actual performance equated to a DI of approximately 160; the fault may be with the drag indices for when TSC are carried. Annex A contains the principal results from Trial NONIYS. Further considerations to be borne in mind when using the ODM are as follows:

a. **Fuel Flows.** No allowance for formation station keeping is made; experience from Exercise RED FLAG shows that visual formation station keeping can impose large fuel penalties.

b. **Use of Auto-throttle.** Trial TUNA showed that although flying in auto-throttle increases the variation of fuel flows minute to minute, there is no significant difference in overall fuel consumption between auto and manual throttle control when flying either manually or in TF at low or medium levels.

c. **Engine Thrust.** Engine thrust of the RB199 is continually adjusted, primarily for engine life reasons, and this requires vigilance when extracting performance data. Of particular note is that the ODM for Mk103 engined aircraft assumes engine thrust to be 38.5 KN; however, SI RB199 No 42, dated Apr 89, reduces the thrust rating to 37.7 KN, making it equivalent to the base standard for Mk101 engines. This has implications for operating safely at high AUW, but of course the thrust level can be raised again should it be needed.

3.(R) **Radii of Action.** The Tornado radius of action depends on many variables including the availability of AAR, weapon load and the recovery base. Annex B lists the planning assumptions made in calculating radii of action and the typical radii declared to SACEUR and to which Tornado could be tasked; these are in accordance with D/DD Air Off/26/1/10 dated Oct 88.

PERFORMANCE COMPARISON

4.(C) Several methods have been introduced for comparing aircraft performance when engaged in combat; the ones normally used are Specific Excess Power (SEP) or Turn Rate Analysis. To reduce the number of variables, performance data is usually presented for a given aircraft mass, configuration and at a nominal altitude. The variables used are speed, turn rate or SEP and applied 'g'.

a. **SEP.** For comparisons between aircraft it is convenient to consider excess power per unit mass; therefore, excess power divided by mass gives SEP. In hard manoeuvring, drag can exceed thrust, the SEP will be negative and the aircraft will lose speed/height. Conversely, if SEP is positive, the aircraft can accelerate/climb while manoeuvring. The tactical significance of SEP comparision is therefore apparent: the aircraft with the higher SEP[1] can dictate the fight by achieving altitude and/or speed advantage while maintaining its 'g' loading.

b. **Turn Rate Analysis**. The turn rate of the Tornado at a given altitude can be compared directly with that of other aircraft by using turn rate graphs. Because of the huge variation in its performance, due to its differing configurations, this is the preferred method of comparing Tornado performance with other aircraft. Annex C contains turn rate information of the Tornado that may be compared [2] to possible adversaries. The parameters chosen for Tornado show that even an unloaded aircraft is no match for the older generation of ex-Soviet fighter in a turning fight - clearly the situation would be far worse against either FULCRUM or FLANKER! The message is clear, do not stay to play with a fighter.

5.(R) **Use of Turn Rate Analysis Graphs**. The main coordinates for the turn rate graphs are, rate of turn in degrees/second and speed in KCAS or IMN, for a DI of 80 at sea-level. Also plotted is a load factor matrix which is directly related to the turn and speed being used. Thus, if required, maximum available 'g' can be determined rather than the available turn rate. On the graphs for Threat aircraft, instantaneous 'g' or maximum lift (where available) is plotted in green, and maximum sustained 'g' or zero SEP in blue. The point at which the graph peaks indicates the speed for optimum rate of turn at maximum sustained 'g'; this latter value can be read directly from the graph. If the speed is higher than the optimum, additional 'g', if desired, can be applied (thereby increasing the rate of turn) until the speed decays to the optimum. As the maximum instantaneous 'g' is a function of lift, and thus speed, the green line on the graphs for the threat aircraft indicates rate of turn and 'g' with speed. However, the limiting value in this case is the structural or aerodynamic limit of the aircraft - where known this value is represented by a red line. The maximum rate of turn is thus obtained at the intersection of the maximum instantaneous "g" line and the limiting "g" or speed line; this point is known as the corner velocity. As the limiting 'g' value is not necessarily a "break-up value" and may be exceeded in war or for survival, the instantaneous line is extended beyond the limiting line.

6.(C) **Tactical Use of Reheat**. When using the graphs, the disadvantages of using maximum reheat should be borne in mind. Trial ENSTATE showed that whereas the BOZ Infra-Red Decoys (IRD) will generally be successful up to mid-reheat, certainly against the older generation IR seeker heads. Above that engine setting BOZ IRDs will generally fail to decoy an IR missile; in addition, the use of maximum reheat incurs a severe fuel penalty (ratio of fuel consumption Max RH:Max Dry is 6:1 but thrust ratio is only 2:1).

PERFORMANCE AT HIGH AUW

7.(C) Trial TWIBILL and Trial NONIYS both investigated Tornado performance at high AUW. The trials included sorties in the D8 (8 bomb) configuration, where the aircraft weighed in excess of 28 tonnes - more than twice its basic AUW.

---

[1] Because SEP is calculated for a specific speed, a common speed should be used when making performance comparisons.

[2] A direct comparison of Tornado turn performance relative to these aircraft can be obtained by placing the transparent overlay over the appropriate threat aircraft graph.

a. **Trial TWIBILL.** Trial TWIBILL found that in the D8 configuration, the aircraft is comfortable to fly, with take-off and landing presenting no problems. However, in dry power the engines lack the thrust to accelerate the aircraft much above 460 kn until fuel is reduced to about 3,000 kg (24 tonnes), when 480 kn is possible. Acceleration is slow above 420 kn and in view of the maximum speed possible, consideration should be given to using this as a maximum enroute speed if any catch-up capability, without recourse to reheat, is to be retained. Evasive turns using dry power only result in large speed losses which, when combined with slow acceleration, may lose a formation member his position irretrievably. Obviously, 180° turns result in even greater speed losses; up to 100 kn with Mk101 engines at 3g, and even that includes wing sweep changes!

b. **Trial NONIYS.** In light of the handling information in the Aircrew Manual, Trial NONIYS was undertaken to evaluate the operational performance of the Tornado, when carrying 2250 litre UWT. The principal performance parameters are at Annex A. The flying considerations highlighted in the trial were as follows:

(1) Though manageable, the sluggish handling makes OLF impractical at high AUW, particularly in hilly terrain.

(2) The current AUW limit of 28.5 tonnes, coupled with the risk of UWT (when less than $^3/_4$ full) and airframe collision on jettison with mid-flap, allows only UWT empty take-off. Therefore, for the D8 configuration, a departure with empty UWT and then to a tanker is the only likely scenario at present.

(3) Joining a tanker requires very careful energy management and judgement of geometry as any tailchase would be overly prolonged. In the D8 configuration, fuel uplift at the low altitudes necessary is inefficient; the Mk 103 engined aircraft took 5,000 kg from the tanker for an ontake of 3,800 kg and the Mk101 aircraft 5,200 kg for 3,700 kg.

(4) In the training configuration, sensitivity in pitch, particularly when CBLS is carried, makes energy management in the climb critical, OLF unviable, formation approaches uncomfortable and can lead to overcontrolling in pitch on approaches to land (particularly in degraded CSAS).

The trial report concluded that in all the configurations evaluated, the characteristics of the aircraft with the 2250 litre UWT fitted were such that good briefing and regular practice would be required if crews were to cope with the handling anomalies.

Note: Since Trial NONIYS, the 2250 litre tanks have been introduced into service and have been flown on both peacetime training sorties and operational sorties during GRANBY. Experience supports many of the comments made in the trial report although in some areas the report appears overly pessimistic. Squadron experience has shown that the aircraft does become more sensitive in pitch and the relatively low 'g' limits need to be closely monitored to avoid overstressing the aircraft. However, the large tanks do not appear to reduce the envelope of the aircraft or limit the type of flying that can be conducted and are well liked by squadron pilots. A caveat must must however be placed on squadron experience with the 2250 litre tanks, namely **in-service experience of TFR (which currently does not have a peacetime clearance) and OLF has nearly all been over relatively flat terrain).**

With the threat density that could be encountered crossing a FEBA, the current options of either 'straight-line fast and low' or 'tactical manoeuvre' will both require the use of reheat if formation integrity is to be retained as a Tornado must maintain 'fighting speed'. This will require a planned combat allowance for all operational missions because profiles that preclude the use of reheat are unrealistic.

AAR

8.(R) The recommended AAR altitudes are given at Annex A, and also in the Aircrew Manual Book 1. AAR procedures and performance considerations are given at Chapter 8 (of this Section) and ATP 56.

ANNEX A TO
SECTION 5, CHAPTER 3 OF
TORNADO GR1 TACTICS MANUAL

AIRCRAFT PERFORMANCE - TRIAL NONIYS

AIRCRAFT FITS

1.(R) The aircraft configurations used in the trial were:

a. **Training.** 2 x 2250, BOZ/ECM, AIM-9, CBLS, Ammunition Ballast - Fit A.

b. **Reconnaissance/Ferry.** 2 x 2250, 2 x 1500, BOZ/ECM, AIM-9, Ammunition Ballast - Fit B.

c. **Conventional Attack.** 2 x 2250, BOZ/ECM, AIM-9, 8 x 1,000 lb HEMC, Ammunition Ballast - Fit C.

TRIAL RESULTS

2.(C) The results of the trial were as follows:

a. Maximum Practical Altitude after Take-off:

		Mk101	**Mk103**
(1)	Fit A	FL230	FL250
(2)	Fit B	FL170	FL200
(3)	Fit C	Not assessed	

b. Maximum Practical AAR Altitude:

		Mk101	**Mk103**
(1)	Fit A	FL210	FL230
(2)	Fit B	Not assessed	
(3)	Fit C	FL80	FL100

c. Fuel Flow :

(1)	Fit A	FL250, M0.7	39 kg/min
(2)	Fit B	High level, M0.7 Started at 44 kg/min, after 3 hrs	33 kg/min

d. Fuel Flow at low level:

(1)	Fit A	420 KIAS	65 kg/min (average)
		480 KIAS	75 kg/min (average)

(2)	Fit B	420 KIAS	(above 21 tonnes)	70 kg/min
			(below 21 tonnes)	65 kg/min
		480 KIAS		80 kg/min
(3)	Fit C	420 KIAS		82 kg/min
		450 KIAS		95 kg/min

e. Maximum speeds (KIAS):

			Mk101	Mk103
(1)	Fit A	45 wing	518	535
		63 wing	538	557
(2)	Fit B	45 wing	500	520
		63 wing	495	515
(3)	Fit C	45 wing	450	460
		63 wing	446	455

f. Speed decay (2g turn thro' 90°):

(1)	Fit B	At 25 tonnes	30 KIAS
(2)	Fit C	Above 25 tonnes	50 KIAS
		Below 25 tonnes	30 KIAS

OPERATIONAL DATA

3.(R) It is important to remember that the above data is the recorded trial flight information; therefore allowances should be made for operational flying.

TORNADO GR1 DECLARED RADII OF ACTION

PLANNING ASSUMPTIONS FOR CALCULATING RADII OF ACTION

1.(S) In the Operational Policy Statement, (Ref: D/DD Air Off/26/1/10 dated Oct 88), the following assumptions are used in calculating Tornado GR1's radii of action:

a. Perfomance is based on the Advance Edition of the ODM (Jun 80).

b. Fuel mass is factored to be 0.78 SG.

c. HL cruise is at economic power setting (approx M0.7) and the descent made so as to be at low level 75 nm before the FEBA. For 2 Gp, outbound routeing is at low level with the FEBA assumed to be 180 nm from base.

d. Straight line routes to the target are assumed, but an allowance of 700 kg for STC units and 10% of fuel mass for 2 Gp units is included for combat fuel, evasive routeing and manoeuvring, formation flying and weapon delivery profiles.

e. Basic configuration is full internal fuel, 2 or 3 external tanks, 2 EW pods, 2 guns with ammunition and 2 AIM-9 missiles.

f. ECM pods, TSC and external fuel tanks are retained throughout the mision except for strike missions where the fuel tanks are jettisoned when empty.

g. Recovery for attack missions is with 600 kg remaining. Strike missions to recover with 450 kg either at home-base or at a forward recovery base.

h. Speeds:

(1) HL at economic cruise.

(2) LL in friendly territory up to FEBA at 420 kn.

(3) 25 nm across FEBA at Max Dry power.

(4) FEBA + 25nm to 20nm before the target at 480 kn.

(5) For 20 nm either side of target at Max Dry power.

(6) Target + 20 nm to FEBA at 480 kn.

(7) Return through FEBA at Max Dry power.

(8) Return over friendly territory at 360/420 kn.

(9) Climb to HL for return to UK at FEBA + 25 nm.

See Overleaf for Data

DECLARED RADII OF ACTION

2.(S) The declared radii of action for Tornado GR1 are as follows:

a. **Strike (Overland)**[1]

Base	Weapons	Profile	External Fuel[2]	Radius of Action (nm)
Hon/Mar	1 x Sp Wpn	Hi Lo Hi	3 x 1500	501
Hon/Mar	1 x Sp Wpn	Hi Lo	3 x 1500	650[3]
Brug	1 x Sp Wpn	Lo Lo	3 x 1500	375
Brug	1 x Sp Wpn	Lo Lo	3 x 1500	481[3]

b. **Attack (Overland)**

Base	Weapons	Profile	External Fuel[2]	Radius of Action (nm)
Hon/Mar	8 x 1000 lb	Hi Lo Hi	2 x 1500	370
	8 x BL755	Hi Lo Hi	2 x 1500	375
	2 x JP233	Hi Lo Hi	2 x 1500	360
	4 x 1000 lb	Hi Lo Hi	3 x 1500	418
	1 x JP233	Hi Lo Hi	3 x 1500	405
Brug	8 x 1000 lb	Lo Lo	2 x 1500	255
	8 x BL755	Lo Lo	2 x 1500	260
	2 x JP233	Lo Lo	2 x 1500	245
	1 x JP233	Lo Lo	3 x 1500	310

c. **Recce**

Base	Profile	External Fuel[2]	Radius of Action (nm)
Hon/Mar	Hi Lo Hi	2 x 1500	430
	Hi Lo Hi	3 x 1500	475
	Hi Lo Hi	2 x 2250	480
	Hi Lo Hi	2 x 2250	
		1 x 1500	525
	Hi Lo Hi	2 x 2250	
		2 x 1500	570
Brug	Lo Lo	2 x 1500	300
	Lo Lo	2 x 2250	350
	Lo Lo	2 x 2250	
		2 x 1500	430

---

[1] Planning data for Strike Missions is contained in SACEUR's NUCLEAR PLANNING MANUAL (NPM).

[2] Radii of action in 3 tank configurations with 2 x 2250 and 1 x 1500 tanks are increased by approximately 55nm.

[3] Recovery base in AIRBALTAP, distance represents depth of penetration from home base.

ANNEX C TO
SECTION 5, CHAPTER 3 OF
TORNADO GR1 TACTICS MANUAL

TORNADO AND THREAT AIRCRAFT PERFORMANCE

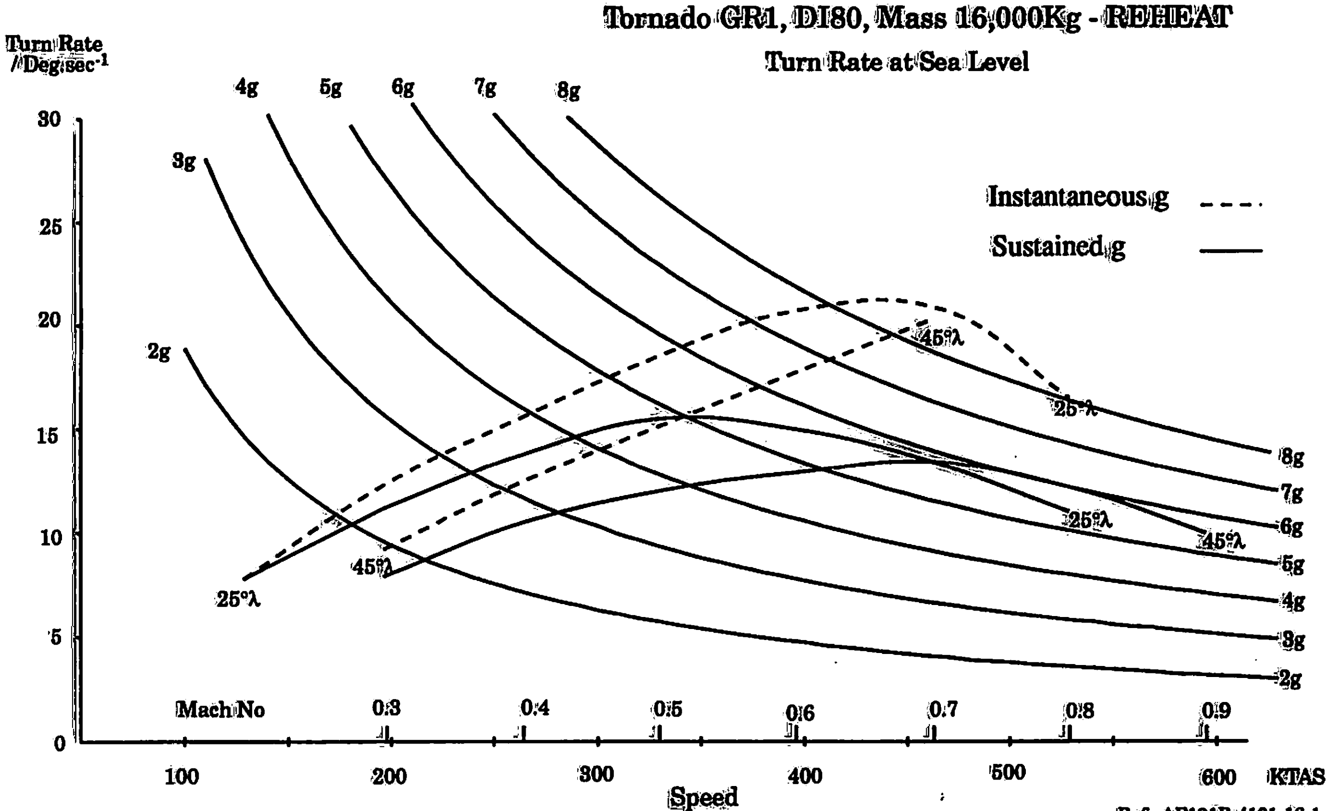
1.(R) This Annex illustrates graphically the performance of the Tornado GR1 and potential threat aircraft using the arguments of turn rate (degrees per second) against speed (KTAS and Mach Number) at Sea Level. The Tornado graphs are also overprinted with a matrix of 'g' which can be used in lieu of turn rate if required.

2.(R) The Tornado graphs are printed on acetate sheet so that they can be overlaid on those of the threat aircraft. Because of the difficulty of producing colour on acetate sheet, the instantaneous and sustained lines are shown as black dotted and black continuous lines respectively. As all the graphs have been produced to the same scale, the Tornado 'g' matrix can be overlaid and used to extract 'g' data from the threat aircraft graphs also.

3.(R) Data is provided for the following aircraft:

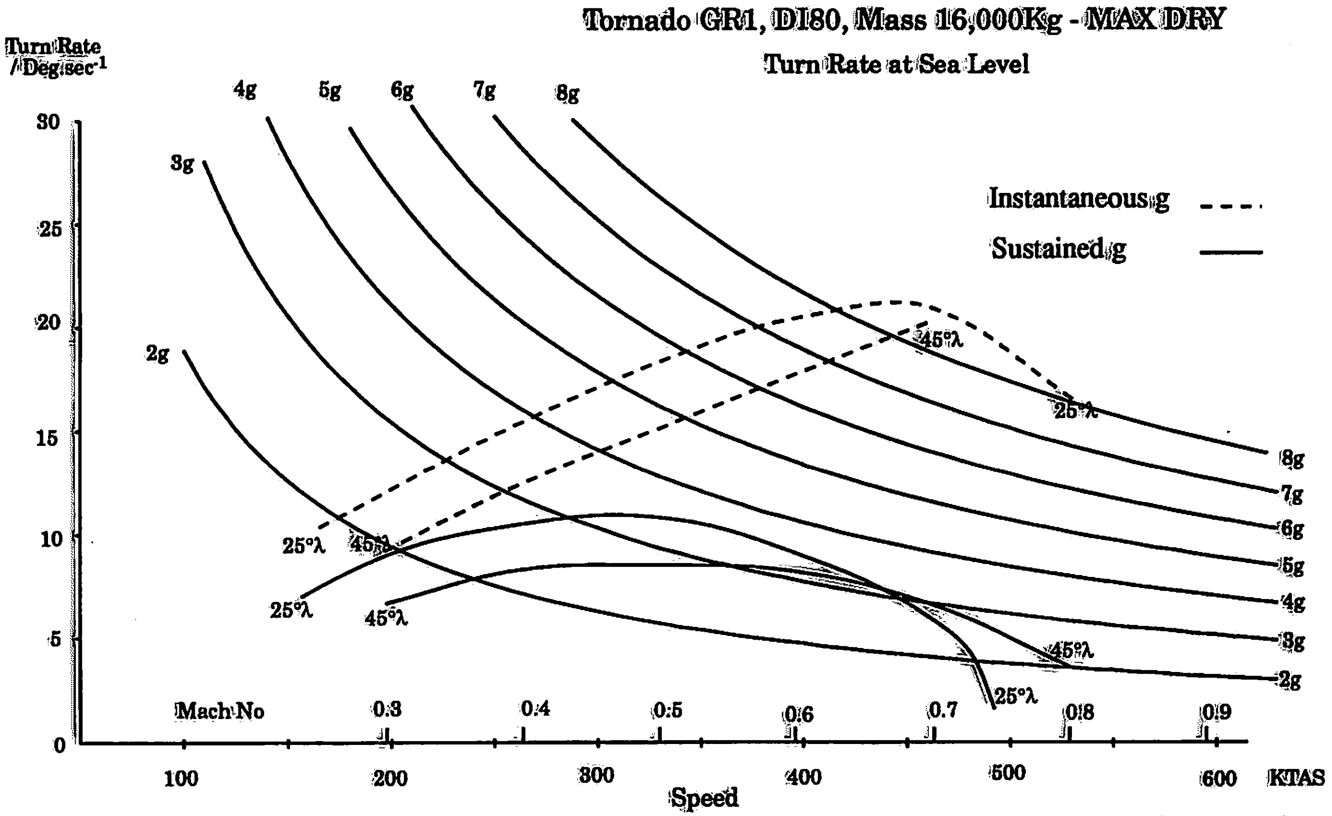
a.	Tornado GR1, DI 80, 16,000Kg, REHEAT	Figure 5-3C-1
b.	Tornado GR1, DI 80, 16,000Kg, MAX DRY	Figure 5-3C-2
c.	FISHBED J, 4 x ATOLL, 15,050Kg	Figure 5-3C-3
d.	FITTER F, 4 x ATOLL, 13,000Kg	Figure 5-3C-4
e.	FLANKER, 2x AA-10 & 2 x AA-8, 18,250Kg	Figure 5-3C-5
f.	FLOGGER G/K, 2 x AA-7 & 4 x AA-8, 13,800Kg	Figure 5-3C-6
g.	FOXBAT E, 4 x AA-6, 29,650Kg	Figure 5-3C-7
h.	FROGFOOT, Pylons Only 50% Fuel,10,360Kg	Figure 5-3C-8
i.	FULCRUM, 2 x AA-10 & 4 x AA-11, 13,700Kg	Figure 5-3C-9
j.	Mirage 5, 2 x AAM & 2 x U/W Tanks/Bombs	Figure 5-3C-10
k.	F 15 Eagle	Figure 5-3C-11

INTENTIONALLY BLANK



Ref: AP101B-4101-16-1

Figure 5-3C-1 (R) - Performance at Sea Level - Tornado GR1, DI 80, 16,000Kg, REHEAT



Ref: AP101B-4101-16-1

Figure 5-3C-2 (R) - Performance at Sea Level - Tornado GR1, DI 80, 16,000Kg, MAX DRY

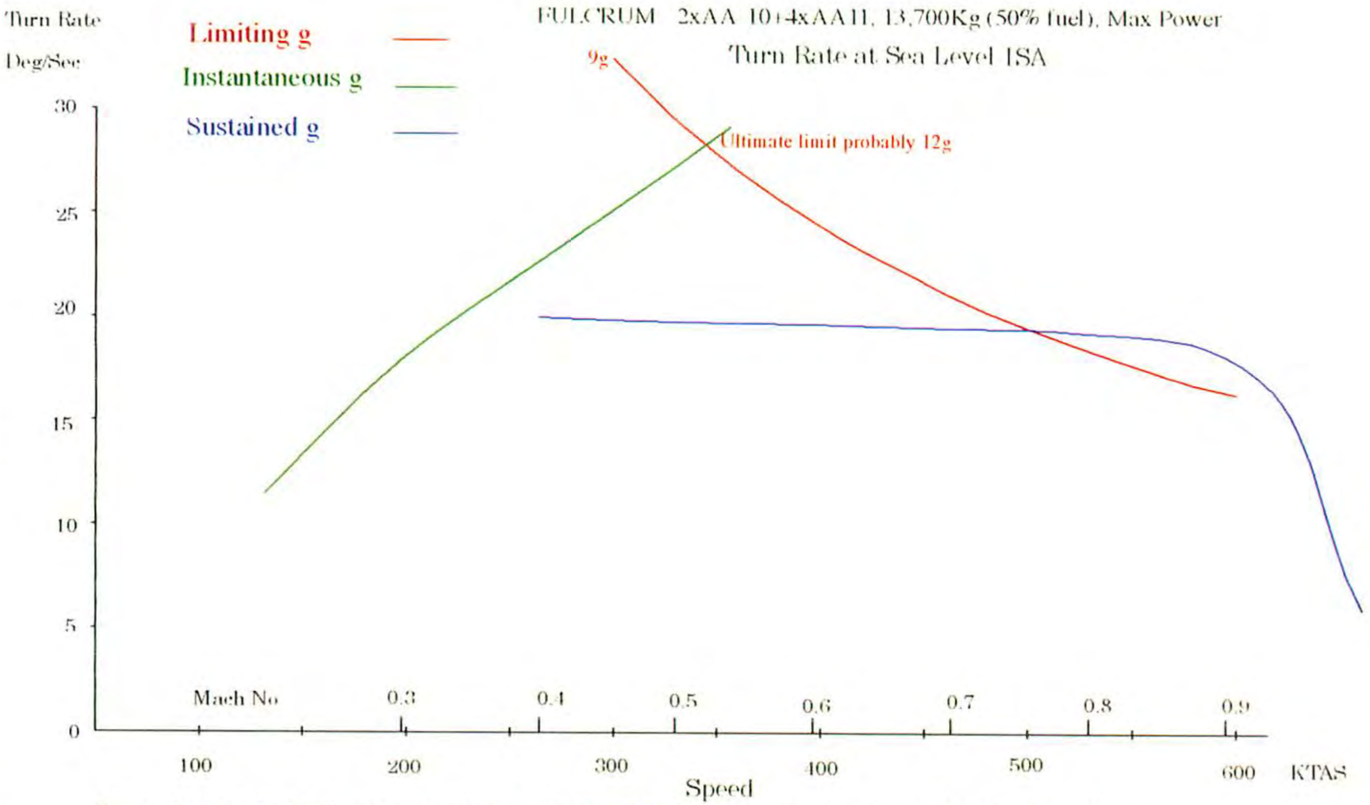


Figure 5-3C-9 (S) - Performance at Sea Level - FULCRUM, 2 x AA-10 + 4 x AA-11, 13,700Kg Max Power

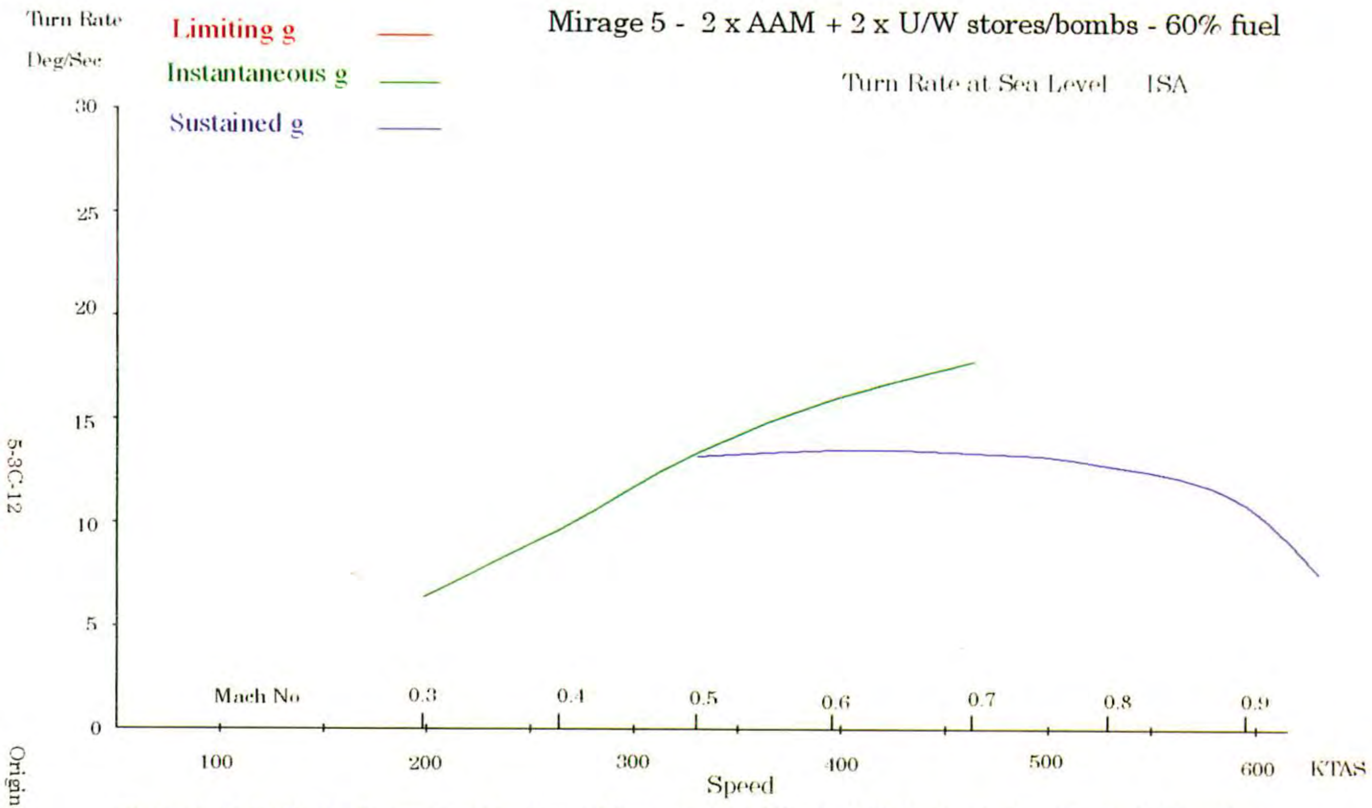


Figure 5-3C-10 (S) - Performance at Sea Level -Mirage 5, 2 x AAM + 2 x U/W Tanks/Bombs, 60% Fuel, Max Power

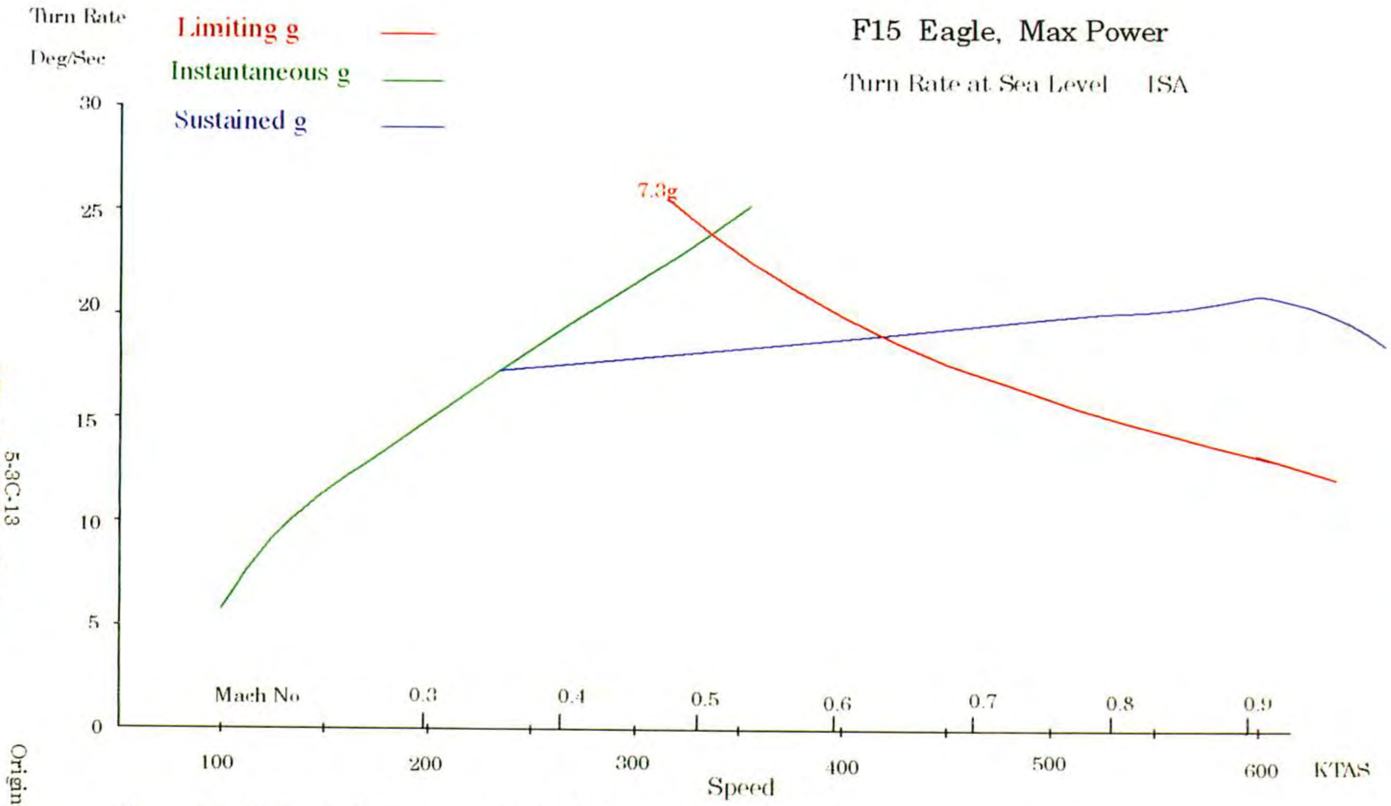


Figure 5-3C-11 (C) - Performance at Sea Level - F15 Eagle, Max Power

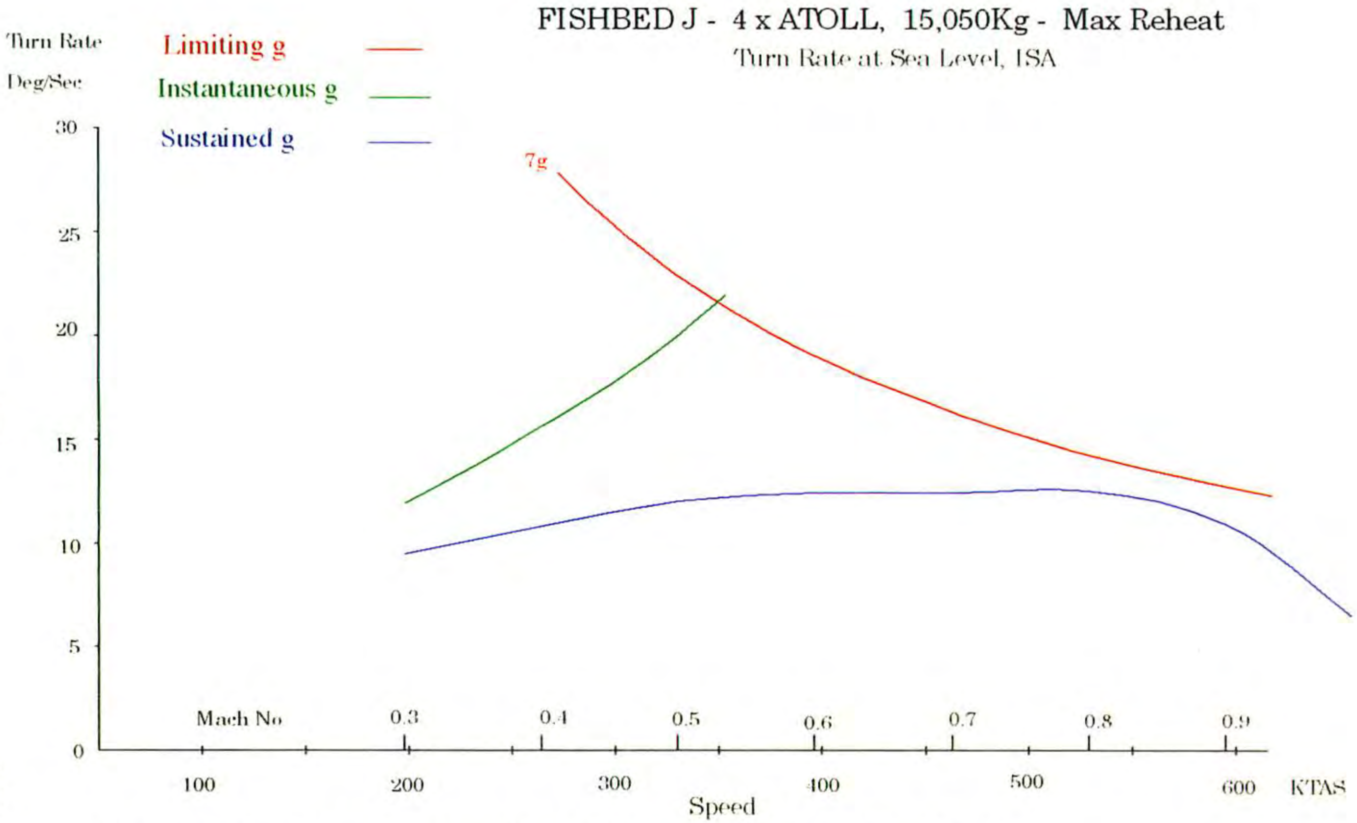


Figure 5-3C-3 (S) - Performance at Sea Level - FISHBED J, 4 x ATOLL, 15,050Kg Max Power

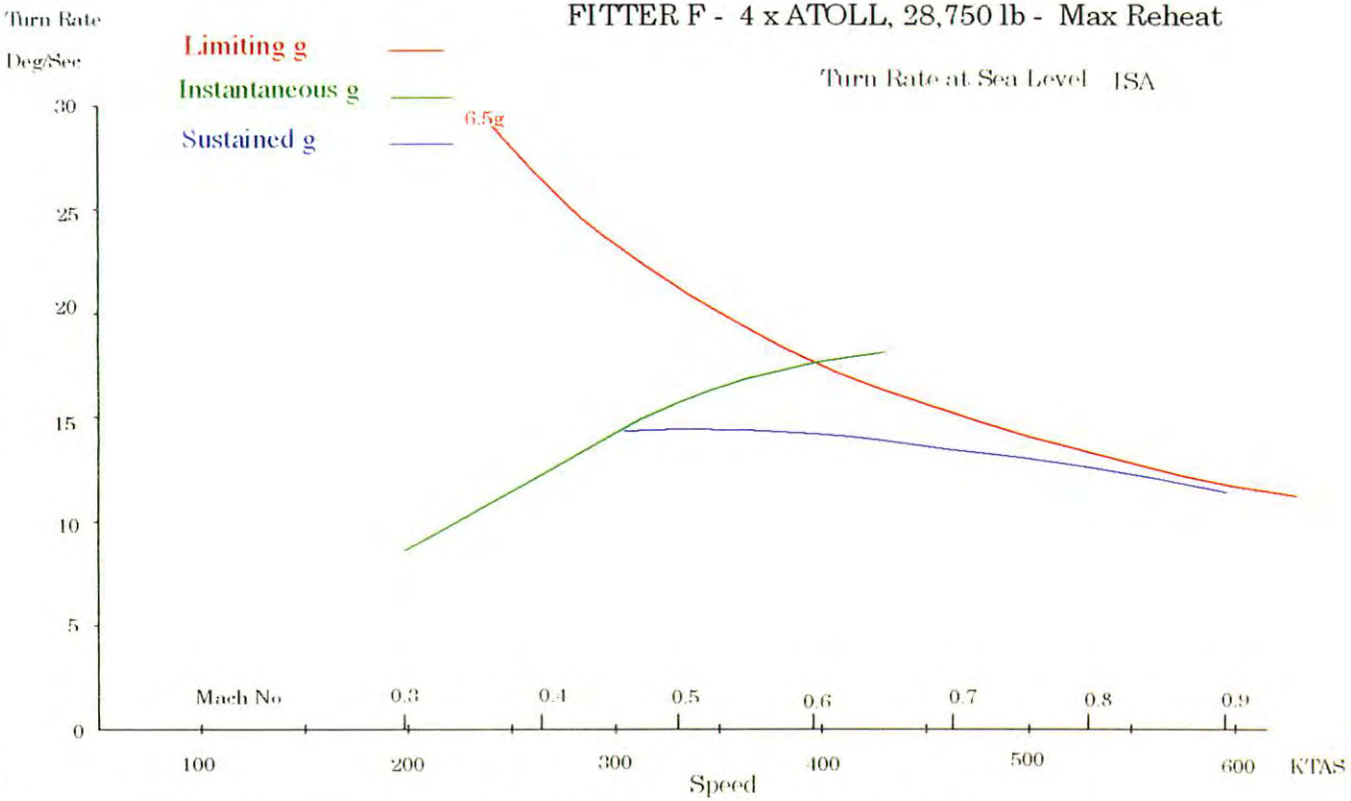


Figure 5-3C-4 (S) - Performance at Sea Level - FITTER F, 4 x ATOLL, 13,000Kg Max Power

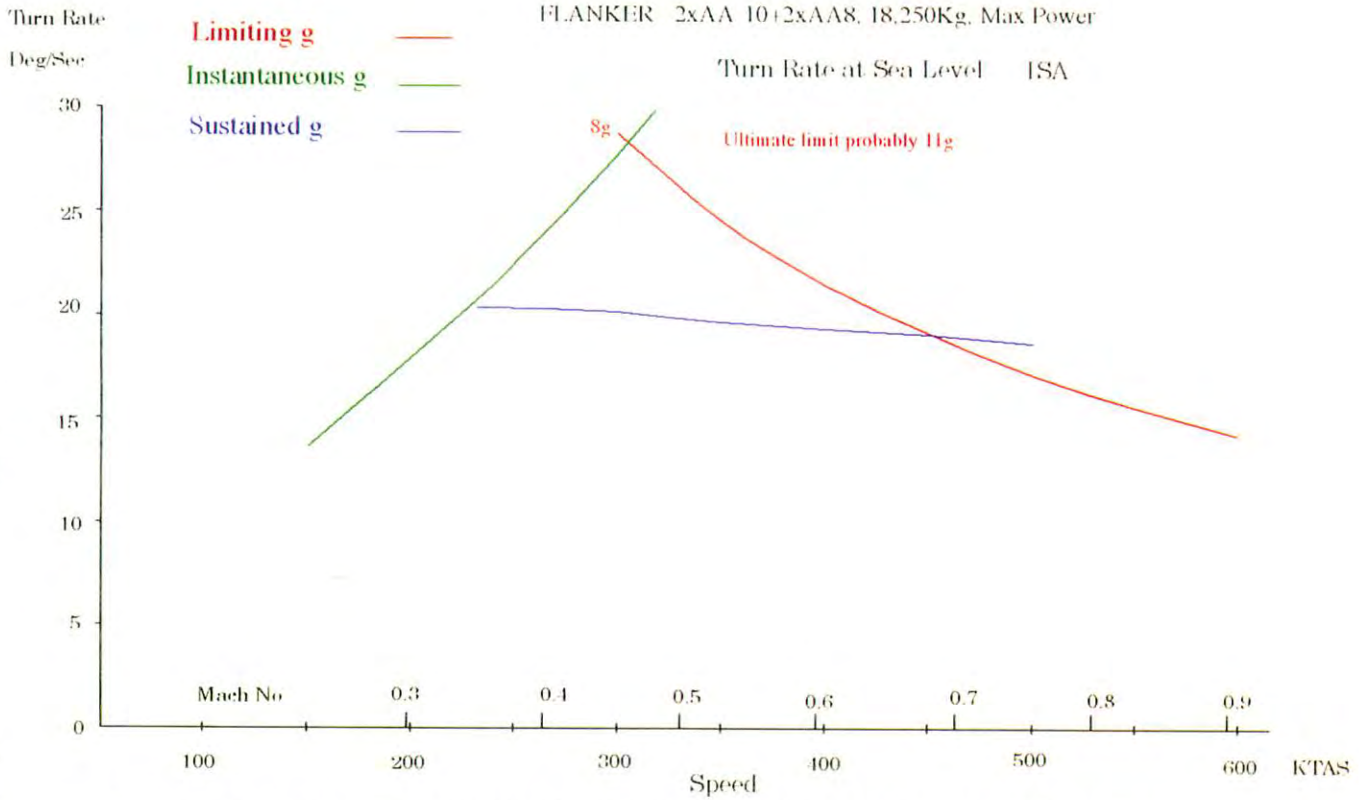


Figure 5-3C-5 (S) - Performance at Sea Level - FLANKER, 2 x AA-10 + 2 x AA-8, 18,250Kg Max Power

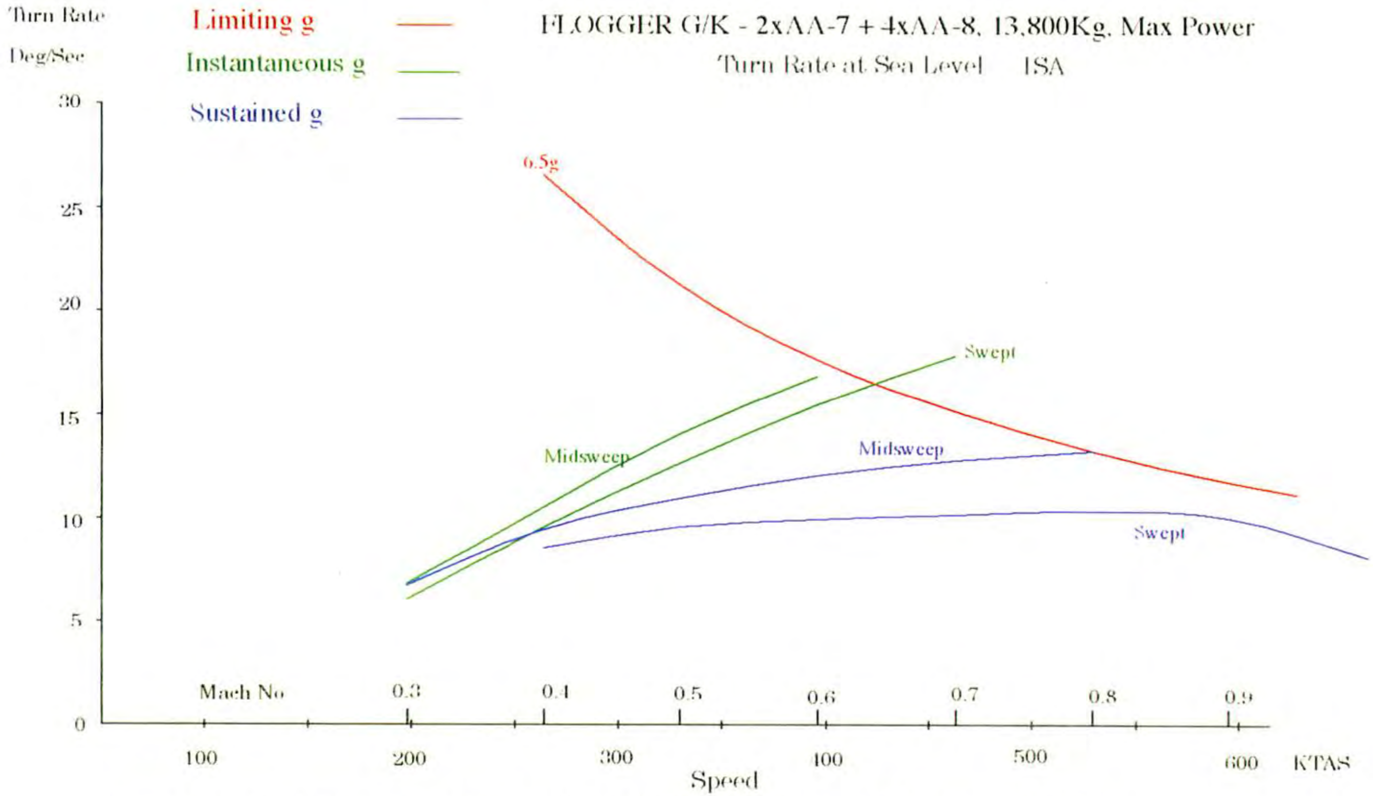


Figure 5-3C-6 (S) - Performance at Sea Level - FLOGGER, 2 x AA-7 + 4 x AA-8, 13,800Kg Max Power

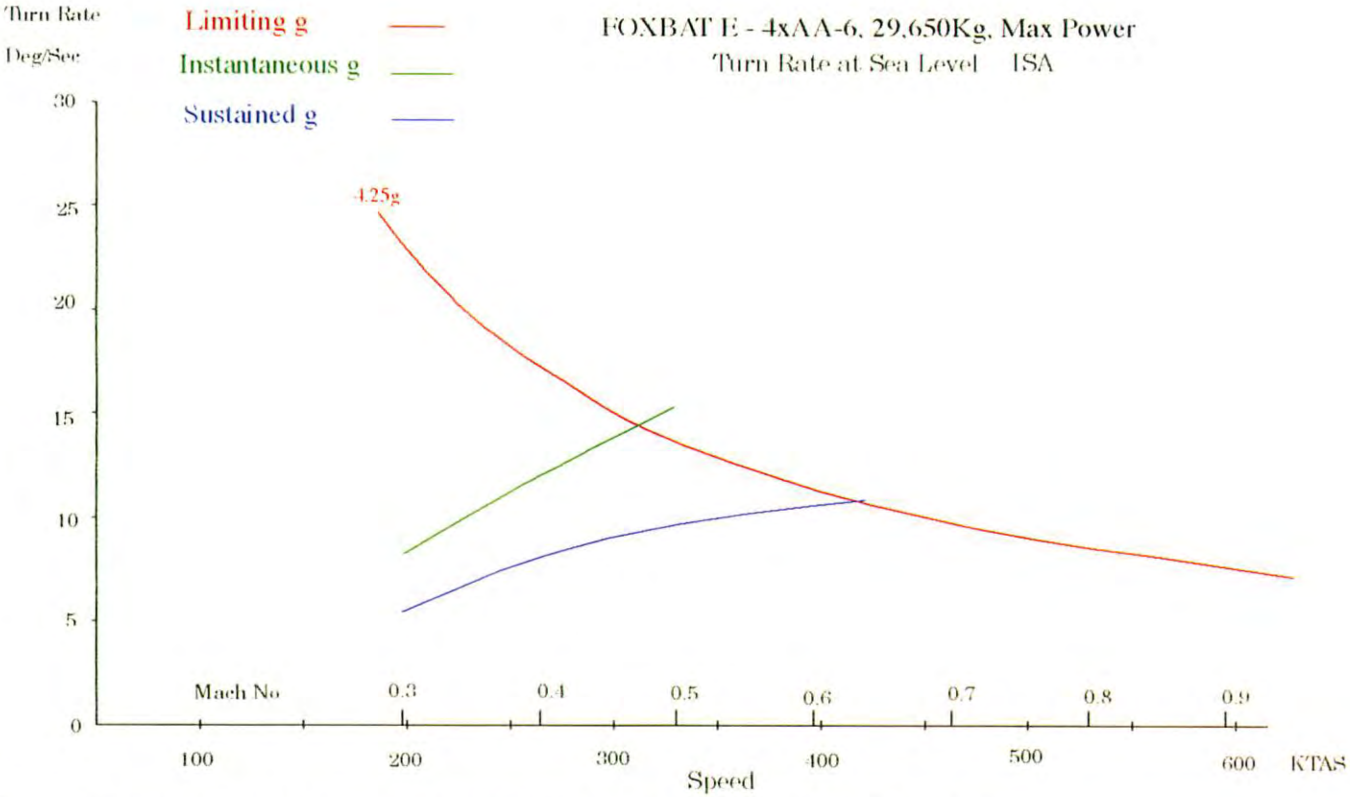


Figure 5-3C-7 (S) - Performance at Sea Level - FOXBAT E, 4 x AA-6, 29,650Kg Max Power

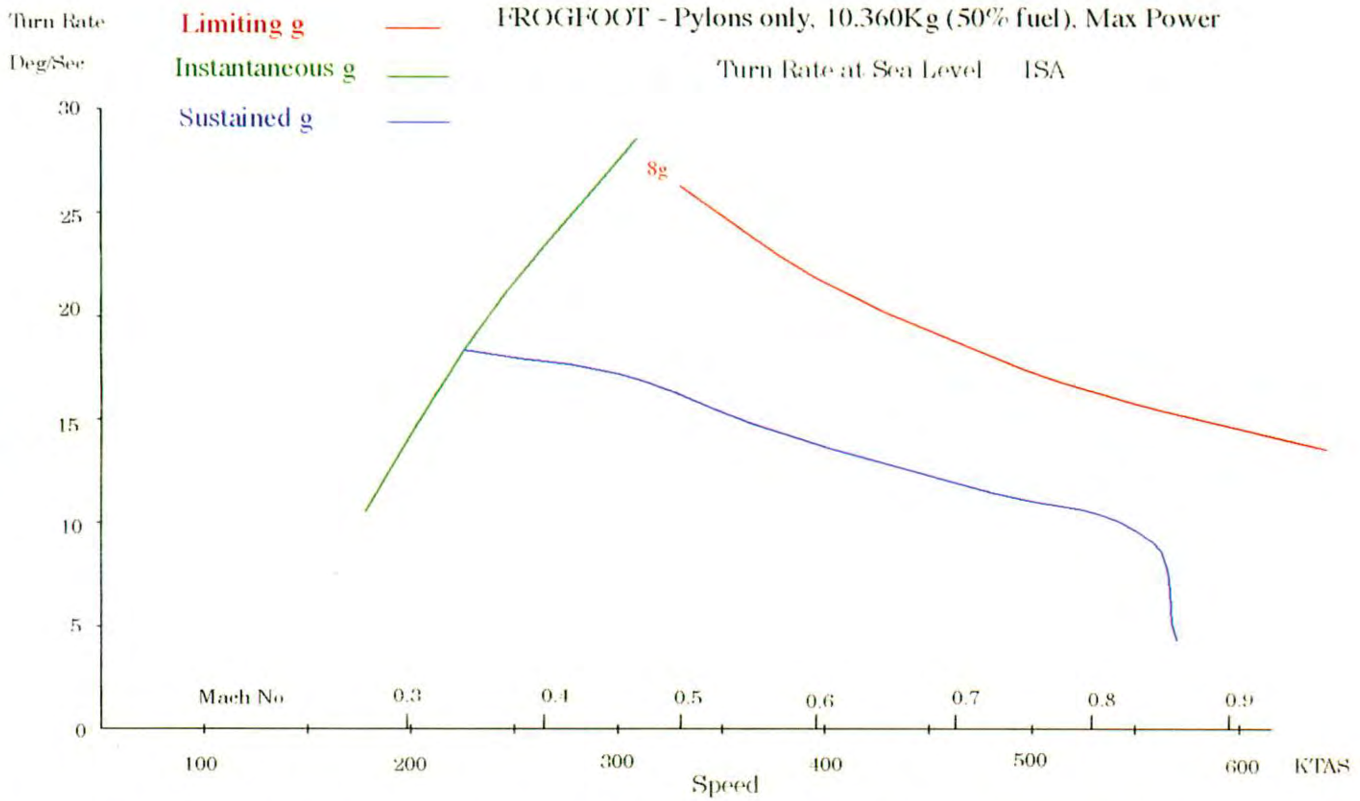


Figure 5-3C-8 (S) - Performance at Sea Level - FROGFOOT, Pylons Only (50% fuel), 10,360Kg Max Power

CHAPTER 4 - MISSION PLANNING FACILITIES AND PROCEDURES

INTRODUCTION

1.(R) Accurate and comprehensive planning is the cornerstone of success for any mission; for Tornado missions this is especially true. The avionics and weapon aiming system of the Tornado is capable of producing extremely accurate results but, as for any computing system, the accuracy of the results is largely dependent on the accuracy of the data on which the calculations are based. Previous data bases used for planning missions, such as the 1:50,000 scale map, have proved to be unsuitable for the completion of successful blind attacks and a new data base with new planning techniques has had to be procured for the Tornado force. In addition much progress has been made by reconnaissance and intelligence agencies in the provision of information to enable greater study to be made of possible conventional OCA and AI targets. This chapter will describe the planning facilities available to Tornado crews and suggest considerations and procedures for planning visual and non-visual missions. ALARM specific planning is covered separately at Section 10.

PLANNING FACILITIES

2.(C) **Information Sources.** Before planning a mission, as much information as possible should be gathered from a wide variety of sources. The broad picture of the position of the target, its surrounding area and defences can be obtained from a 1:500,000 intelligence map which is annotated with enemy radars and defences. Before detailed planning is started, however, the following documents should be consulted:

a. '200 series' maps.

b. Automated Tactical Target Graphics (ATTG).

c. Target Information Supplement (TIS).

d. Conventional Target Planning Document (CTPD).

The CTPD is particularly comprehensive and includes a target description with area defences, photographs of suggested initial points and offsets, and many detailed photographs of the target elements with accompanying descriptions. The compilation of the CTPDs is a complex and laborious task and for some targets a CTPD may not exist. However, when available, maximum use should be made of these excellent planning aids. If the target has been the subject of a preplanned option in the past, it is probable that Target Planning Folders (TPFs) or Combat Mission Folders (CMFs) already exist, in which case they too may be used as sources of information.

3.(R) **Planning Aids.** The electronic aids available for mission planning are the Cassette Preparation Ground Station (CPGS), the Point Positioning System (PPS), desk top or hand-held computers, and colour copiers.

PRE-PLANNED OPTIONS/ ON-CALL TASKING

4.(C) As discussed in Chapter 1 of this section, OCA missions may either be in the form of pre-planned options, or on-call tasking. Pre-planned options may be planned in slow time. On-call tasking must be fully prepared in whatever time is available (See Para 6). The remainder of this Chapter deals with the considerations of on-call tasking.

TASK RECEIPT

5.(R) Under intensive tasking conditions the task may be received before all the crews are assembled to plan it. The leader should follow SOPs and complete as much initial preparation as possible whilst awaiting other members of the section. Normally however, squadrons will have SOPs for the allocation of responsibilities to formation members. A suggested planning guide is at Chapter 7.

PLANNING CONSIDERATIONS

6.(C) **Time Available.** The first consideration after receipt of a task is the amount of time available to complete the planning and briefing. The planning and briefing times available for ASAP TOTs are stipulated in the COMTWOATAF SUPPLAN 32001B and are generally as follows:

a. **Night/ All - Weather Missions.**

(1) 1 to 4 aircraft - 180 mins.

(2) Plus 30 minutes for each additional block of 4 aircraft.

(3) Plus 30 minutes for missions requiring air-to-air refuelling.

(**Note**: For SSR(A) Tornados the planning stipulated in FERAL CYGNET 10606D is 4.5 hrs, including missions briefing, for all formations).

b. **Other Missions (except CAS).**

(1) 1 to 4 aircraft - 60 minutes.

(2) Plus 30 minutes for each additional block of 4 aircraft.

(3) Plus 30 minutes for missions requiring air-to-air refuelling.

It should be borne in mind that the above times commence from the receipt of the task on the station, not on the squadron. The SUPPLAN 32001B also details procedures for OAS Missions, specified TOTs and Paveway missions. To streamline the planning sequence a target library, where possible, should be maintained either on the squadron or at station mission planning; this should hold prepared routes and attack plans or probably targets which will require a minimum of updating immediately prior to the sortie being flown. If there is insufficient time to plan, brief, and meet a specified TOT, a revised TOT must be requested.

7.(R) **Weapon Load.** Following the declaration of a Formal Alert or Counter Surprise State, Tornados are to be loaded with the best OCA weapons available. For other missions the weapon load will normally be specified as a Standard Conventional Load (SCL) on the ATM. All aircrew should be conversant with the SCLs for Tornado but a planning room aide-memoire chart is useful. Normally the suitability of the weapon load will have been checked by the Mission Monitor Cell (located at Wg Ops) but, should the leader wish to alter all or part of the load, he should advise squadron operations as early as possible. If a change is required, even to fuze settings, it must be actioned rapidly as weapons loading may have started. Under most circumstances it will not be practicable to change weapon loads and re-tasking or a later TOT may have to be requested.

8.(C) **AAR.** Having confirmed the weapon load and noted the target position it is possible to decide whether AAR will be required. If AAR is required and is not detailed in the ATM, as much notice as possible must be given to enable the tankers to be tasked and RV procedures to be briefed. If insufficient fuel is available to a formation the route may have to be altered, speeds adjusted, or formation size reduced; if no tankers are available, an alternative landing airfield may be arranged, or the mission cancelled. In any case the tasking agency must be kept informed.

9.(R) **Visual/ Non-Visual Conditions.** The Tornado has a major advantage over other aircraft in its ability to make successful conventional attacks on targets in non-visual conditions. The weather and time of day will however be important factors to consider before a plan is conceived. In visual conditions planning is made simpler; a visual attack may be made, and when route planning only the track of the lead aircraft need be plotted as the remainder of the formation can maintain position visually. In non-visual or mixed weather, however, when blind attacks will have to be made planning is a complex and onerous task; in particular care must be taken to ensure that suitable offsets are selected and accurate offset calculations are made. Additionally, routes must be planned in such a way as to enable formations to convert from visual to non-visual conditions and vice versa with ease and safety. To account for eventualities, such as a delay in TOT or changeable weather, it is highly recommended that all possible sorties use the time allocated (see Para 6) to plan for non-visual conditions. (Planning methods are discussed more fully in Chapter 6 of this Section).

10.(R) **Number of Aircraft.** The number of aircraft required for a task will largely be determined by the ATM, and will have an effect on the complexity of plan required and the planning time available. OCA and AI mission will normally be tasked as multiples of four aircraft whereas BAI missions will be tasked as pairs of aircraft.

11.(R) **Other Information.** Before planning is complete crews must obtain the appropriate IFF codes, traverse level information, and PELE (bearing in mind the date if flying over midnight). Crews will also need to check recovery procedures for their landing base and obtain a current intelligence brief as it affects the route with particular emphasis placed on the positions of the FLOT and FSCL. Crews should also receive an escape and evasion brief with a map.

12.(C) **Formations.** Visual formations are comprehensively dealt with in the CTTO Tactical Handbook and will not be discussed further in this Manual. For Tornado operators however, formations must be suitable for both visual and non-visual conditions. Some examples are below:

a. **Goose.** Goose formation is shown at Figure 5-4-1:

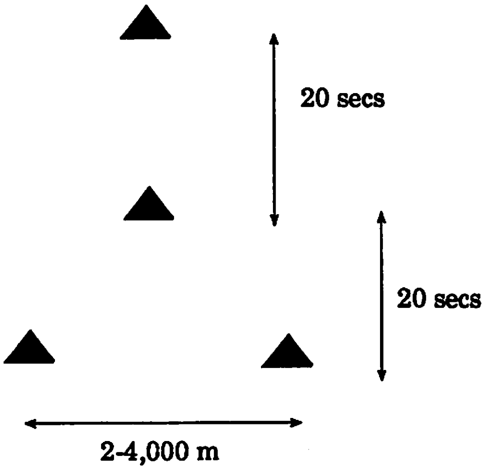


Figure 5-4-1(R) - Goose Formation

This formation is flexible and manoeuvrable, with good 'look-out' potential and gives ample opportunity for Nos 2, or 3, or 4, to achieve an AIM 9L 'Sandwich' if an attacking fighter were to roll in behind Nos 1 or 2 aircraft. Goose is also simple requiring just single track planning. In the event of poor weather, Nos 1, 2 and 3 of the formation will all be adequately spaced at 20 secs (2.1 nm at 420 kn or 2.7 nm at 480 kn) and can fly TF in line astern. Only the No 4 will have to establish a 20 sec stretch on No 3; the method is discussed in Section 6

AL2 (MS)

The disadvantage of this formation is that in VMC, the Surface-to-Air Defence Systems (SADS) are basically presented with three aircraft in line stream (albeit Nos 2, 3 and 4 may offset from planned track by 2,000 - 3,000 m). In IMC four aircraft in line astern might give anti-aircraft defences ample warning of the approach of the Nos 3 and 4. Additionally any ECM employed by the leading aircraft such as chaff or Skyshadow jamming will have an adverse effect on the performance of the TFR of the following aircraft. One of the lessons arising from RED and GREEN FLAG Exercises has been that the problems of flying TF trail at 20-30 sec separation were significantly increased by the presence of SADS, chaff and jamming.

b. **Card**. Card formation is a classic visual formation, which may be expanded to allow for non-visual conditions. Again Card formation, shown at Figure 5-4-2, is flexible and manoeuvrable with good lookout, and Nos 3 and 4 can achieve an AIM 9L 'Sandwich'. In the event of bad weather, however, all aircraft maintain their positions which requires parallel tracks to be planned with a minimum of 4,000 m spacing extending the planning time required. The planned spacing will very much depend on the anticipated accuracy of navigation system (During Operation GRANBY this figure was doubled on some occasions due to the paucity of accurate fix points). This formation reduces any advance warning given to SADS, but again Nos 3 and 4 could be adversely affected by ECM from 1 and 2.

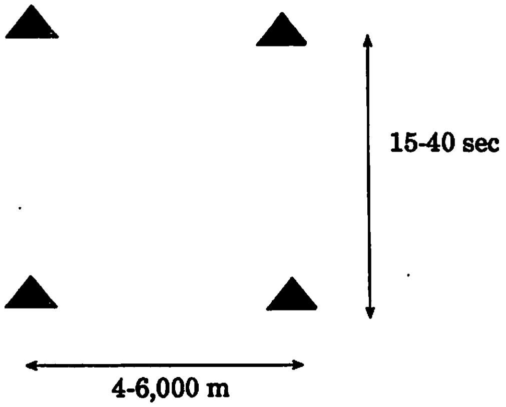


Figure 5-4-2(R) - Card Formation

c. **Battle Pair**. The formation resulting in the least mutual interference between aircraft is probably the Battle Pair.

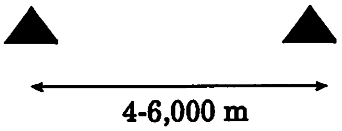


Figure 5-4-3(R) - Battle Pair

The problem with both Goose and Card is that trailing aircraft are forced to fly line astern giving anti-aircraft defences warning of their approach and suffering the risk of interference from preceding aircraft ECM systems. The Battle Pair is more flexible whilst allowing adequate look out to be maintained, but there is no chance of achieving a 'Sandwich' without manoeuvre - which even then would be doubtful against a modern agile fighter. In the event of bad weather parallel tracks could be flown with no interference from the ECM systems of other aircraft, but to achieve four or more aircraft over the target with time compressed TOTs would require availability of suitable routes, and sufficient

AL 2 (M5)

fuel to utilise them - both rare luxuries. If sufficient routes are not available, separation between TOTs could be expanded, allowing pairs of aircraft to follow at long random trail distances to provide an element of surprise to the target defences.

The choice of formation is a difficult decision and ultimately rests with the squadrons. Often circumstances will dictate the choice but some points to be considered are visual/non-visual conditions, planning time available, time available over the target, routes available to the target, and positions of the ground and air defences.

13.(R) **SUPPLAN MIKE.** Before definitive route planning commences the formation leader must ascertain which of the COMAAFCE SUPPLAN 35001M routes will be available during the time of the mission. These routes will be shown as active or inactive on the squadron intelligence map and should also be stored in the CPGS so that they can quickly become part of the route plan.

14.(S) **Target Area Intelligence.** Everything possible should be learnt about the target and target area defences. Their positions can be found from intelligence maps and the documents listed in Para 2. Current intelligence however should be consulted to check the serviceability of the systems as, by the second or third day of a conflict, target defence systems may have been neutralised. These may range from any combination of fixed missile sites to mobile SAMs (radar, IR or visually aimed), or AAA radar (visually laid or barrage AAA).

15.(U) **Target Area and Route Planning.** When all the foregoing information has been collected the Target Area Planning and Route Planning can be done. These two subject are covered fully in Chapters 5 and 6 of this section.

16.(R) **NBC.** Planning under adverse NBC conditions should be practised frequently since procedures which are otherwise simple and straightforward become awkward and laborious with the addition of a gas mask and NBC clothing. During planning, communication between formation members can become difficult and confusing thus emphasising the need for all formation members to be aware of their briefed tasks (detailed in Chapter 7 of this Section), and SOPs referred to earlier in this chapter. It is even possible that during intensive tasking, and when operating under NBC restraints, crews will stay in the HAS between sorties whilst other crews complete the sortie planning for them and draw up the maps in the PBF. The plan and routes with Int/IFF/FLOT updates would then be sent out to the crews with no face-to-face briefing and this demands a high degree of standardisation between crews and squadrons. The major advantage of this system for the tasking agencies is the time saved by the crews not having to complete decontamination and lengthy dressing procedures between sorties.

INTENTIONALLY BLANK

CHAPTER 5 - TARGET AREA PLANNING

INTRODUCTION

1.(R) The outline target area plan should be prepared before route planning is commenced. Unless it has already been specified in the ATM, the first priority is to select the most suitable weapon(s) for the target/DMPI. Thereafter, the attack plan can be completed ~~using the~~ CONSIDERING THE following ~~sequence~~: FACTORS

a. Consider target acquisition which, even by day, should allow a blind attack.

b. Confirm the DMPI and determine the aimpoints.

c. Ascertain the best attack direction/LOA.

d. Select the appropriate attack profile.

e. Consider primary/reversionary weapon aiming procedures, and select and calculate offsets.

f. Plan integrated formation attacks.

g. Plan alternative TOTs.

2.(R) This chapter is intended primarily for planning low level attacks although many of the points made below are also relevant to medium altitude operations. Detailed planning considerations for medium altitude FF bombing and LGB attacks are given at Section 9, Chapter 1 and Chapter 2 respectively.

TARGET/OFFSET ACQUISITION

3.(C) Although the GMR will probably be used during most Tornado attacks, crew study of the final run-in and attack is vital. Being aware of all the features on the target run will not only increase confidence during the attack but is also more likely to enable a successful attack to be made should aircraft systems fail. Radar acquisition of at least one OAP or of the target aimpoint is fundamental to a successful radar attack and the following factors should be considered.

a. **Radar Significant Features**. At operational heights and speeds overland, trials have shown that typical target aimpoints are unlikely to be seen on radar at sufficient range to permit a "direct" radar attack. This is particularly true of loft attacks but will usually apply to laydown deliveries also. Therefore, offset attacks, using the most accurate offset-to-target calculations, should always be planned.

b. **Terrain Screening/ Aircraft Height**. The importance of terrain screening in the target area cannot be over emphasized, but of course it may also screen the target. Similarly, lowering the attack height will reduce the detection range of the OAP and target aimpoint, eg halving the height reduces radar acquisition range by about 30%.

c. **OAP Selection**. Radar significant OAPs should be planned even in visual conditions. At least one offset should be planned near the 20 nm limit, to ensure the system is as accurate as possible before entering the target area which is likely to provide a very high-workload environment.

(1) **Choice of Radar Offsets**. A radar OAP should be small and yet

AL2(NS)

easily distinguishable; these ideals tend to be incompatible so, to overcome the problem, at least 2 offsets should be used. The first OAP should be a large feature to overcome the possibility of large navigation errors and then to permit smaller point(s) to be used to achieve the required accuracy (Trial SPARE - refers). Radar OAPs should be less than 45° off planned track at the ranges at which they would be used. When choosing large features, they should have positive edges or corners that permit accurate determination of the exact offset point required. The smaller and the more discrete the offset, then the closer to track it should be to allow as much time as possible for it to be acquired when flying at operational heights. For low level attacks an all-sensor offset should be selected that is close to track and no closer than 2 nm before the target or loft pull-up point; for "along runway" JP233 attacks this distance becomes 4 or 5 nm. These distances are a compromise between the requirements for continuous refinement of the aimpoint and the distance needed for the aircraft to achieve normal auto-attack steering on the required LOA. Man-made OAPs should be used with caution because the radar signature may be changed markedly by passive radar deception or damage caused by earlier attacks. Furthermore, woods while producing excellent radar returns may have been cut down since the photograph was taken or the map printed.

(2) **Choice of Visual OAPs.** Visual OAPs should be readily identifiable and must be as close to track as possible to ensure that they will appear in the HUD. Although ideally all offsets should be radar significant, non-radar discrete features may be chosen in visual conditions, not only for the obvious back-up in case of radar failure, but also because they can assist in establishing the LOA or enable the pilot to aid the navigator find and refine a discrete radar points.

(3) **Choice of All-Sensor OAPs.** Ideally, the characteristics of both radar and visual OAPs should apply to all selected offsets but how the offsets will be used on the target-run needs to be considered carefully before they are entered into the MC as all-sensor OAPs.

d. **Offset Calculations.** The most expedient method of calculating offsets is given at Annex A.

e. **Visual Target Acquisition.**

(1) **In-Flight Visibility/Weather.** In hazy conditions the relative position of the sun has a dramatic effect on in-flight visibility; heading directly into sun can reduce the forward visibility to near zero. Even in clear conditions, when flying directly into sun, crews will probably be unable to maintain heights below about 150 ft MSD and the HUD can become unusable. While laydown/shallow dive passes are most

vulnerable to a low sun, pulling up into a high sun for a loft attack can make HUD steering difficult to follow. Aiming points and attack directions for multi-aircraft coordinated raids should be chosen with the forecast wind in mind to minimize target obscuration from drifting smoke. During winter, any recent snow should be noted because it tends to highlight woods and towns but may obscure minor roads, little used railways and frozen lakes.

(2) **Target Size and Contrast.** Target size, vertical extent, composition and the contrast of the target against its background, significantly affects the detection range. It should be assumed that military targets will always be camouflaged or toned-down. Target movement and exhaust smoke can increase detection range.

(3) **Cockpit Environment.** Targets may be masked behind the canopy frame or HUD mounting but moving the head should alleviate the problem. Light attenuation and reflections through dirty optical surfaces, including the HUD, caused by salt spray, squashed insects or dust impedes visibility markedly and impedes operational low flying. Always start out with clean optical surfaces.

f. **Electro-Optical (EO) Sensors.** Although the introduction of FLIR is still someway off and the NVG is still to enter day-to-day squadron service, they have already been the subject of evaluations by the SAOEU so it is perhaps worth mentioning some of their initial findings. EO sensors do NOT turn night into day, but rather they allow or enhance night operations under favourable conditions. To use them effectively requires an accurate navigation system (in Jaguar trials this was defined as within 0.2 nm) because only points in the near foreground can be seen by NVGs and of course FLIR can only be used against objects in the HUD FOV. Also, moon position has to be taken into account and cultural lighting has to be avoided as both markedly effect NVG range. An offset moon gives the best shadows and therefore the best results. With FLIR, trees tend to blend into the background denying these often excellent daytime features for night time use. Therefore, it is suggested that an initial solid fix/OAP is used (probably with radar) to update the kit and to allow the EO sensors to be used against large, near track features to permit a stealthy final attack. Assessment of both GEN 2 and GEN 3 NVGs was carried out by the SAOEU under Trial PEACH. More information on NVG operations is given at Section 12 - NVG Operations.

g. **Crew Workload.** Crews may be distracted from their target detection task if engaged by target defences, but much of the target area workload can be reduced by thorough planning. Trial RUBIAN highlighted the high pilot workload during loft attacks and that the navigator may well be busy for periods of any attack. Making all weapon system selections early in the mission and having a positive plan for handling weapon aiming matters, particularly across cockpit, will help to reduce target area workload. Trial SPARE emphasized the need to keep the attack plan as simple as possible and to ensure that the correct height sensor is selected and used; crews need to keep abreast of the continually changing MC software and aircraft systems to make best use of the aircraft. Current deficiencies in cockpit ergonomics, noted in Trial RUBIAN, are in Annex B.

DMPI/AIMPOINT

4.(R) DMPI selection is a complicated problem. DMPIs will normally have been set out in the CMF or ATM. However, when targets are defended by an adjacent SAM site, attacks to neutralize the SAM may be considered appropriate within the task. Option or mission leaders should consult a specialist if advice is required with regard to Weapon-to-Target matching although, if this is not possible, a guide may be found at Chapter 2 Annex A to this Section. Formation members should be able to determine the aimpoints readily from the DMPIs. For formation attacks against large targets using visual techniques, following aircrafts' aimpoints should be upwind of the leading aircraft.

ATTACK DIRECTION/LOA

5.(C) The preceding paragraphs have highlighted the problems of target acquisition and have assumed freedom of attack heading, but the LOA should be chosen to achieve the maximum weapons effects against the target. Thus, the target's type, size and shape, type of delivery, anticipated accuracy and the numbers and types of weapons to be released will have to be considered. As delivery errors are greater in the along-track rather than the across-track sense then, as a general rule, targets should be attacked along their length. However, the following factors should also be taken into account.

a. LOA effects target identification because, either visually or on radar, aimpoints may be masked. Not only should terrain, trees etc be considered but also man-made features; for example hangars may obscure DMPIs.

b. Unless using JP233, line features should be attacked at such an angle that a cut is made having allowed for stick spacing.

c. Certain targets require a set LOA. For example JP233 along runway attacks or low level attacks against bridges.

d. Terrain before and after the target; for concealment on ingress and for protection or for avoidance on egress.

e. Availability of suitable OAPs.

f. Enemy defences; ideally SAM-defended targets are attacked so that the aircraft are flying away from the site when within radar cover, but at least the enemy defences should be presented with the most difficult task.

g. Coordinated formation attacks often require much room to manoeuvre and it is important for crews to appreciate the plan fully and to adhere to it; not only to protect the aircraft from each other and from the weapons effects, but also so that they are not surprised or distracted by colleagues and they retain mutual support for as long as possible.

h. Avoid attacks directly towards a low sun.

i. Forecast wind; for retard bombs for example, attacks into wind have the advantage of reducing stick spacing and, for FF bombs, attacks downwind increase the maximum stand-off range and the bomb impact velocity. However, an across-wind attack would help to clear smoke etc from the DMPI should there be aircraft following.

j. Mobile targets, eg convoys, should be attacked from the rear, along the direction of movement rather than across it.

ATTACK PROFILES/ DELIVERY TYPES

6.(C) **Factors to Consider**. The following factors should be considered when determining the best type of delivery:

a. **Accuracy Versus Attrition**. The method of attack should be chosen to balance the probability of mission success against likely attrition. Invariably, the best weapon-aiming accuracies are obtained from familiar and practised profiles. However, wartime performance is likely to be 2 or 3 times worse than that achieved during peacetime academic training. While for ASD reasons it is desirable to operate to minimum release heights or firing ranges based on a peacetime SD3 (ie the self damage resulting in the loss of an aircraft) risk limit of 10^{-4}, operationally, the tendency will be to fly lower and for commanders to accept the higher risk level of 10^{-3}, even though the slightly lower heights may have little effect on attrition rates. If weapons are dropped below release parameters then they will fail to detonate OR ENTER-POST IMPACT ARMING in the case of bombs or have their effectiveness markedly reduced in the case of JP233. Should this occur, then the OTR will increase resulting in greater overall attrition as more aircraft are exposed to the enemies defences.

b. **Weapon Effects**. The type of weapon carried, the weapon effects required, the release sequence, the minimum release interval, the bomb strike angle, velocity and fuzing should be taken into account when selecting the optimum delivery mode. Further advice on the main weapons and their preferred delivery modes are outlined in paras 7 - 15.

c. **Topography**. A balance should be struck between target acquisition requirements and the need for terrain screening against local defences.

d. **Vulnerability to Target Defences**. As a generalization, defences are becoming increasingly capable at very low levels and the position of enemy defences should be studied carefully to establish if their line of sight can be obscured. However, it bears stressing that flying below weapon dudding height will not only render the sortie ineffective, but may well have no bearing on survivability. The message is simple, ensure minimum release heights are met. Some additional points are as follows:

(1) **Surprise**. To achieve surprise try to be unpredictable. Providing fuel allows, it may be worthwhile to attack from 'around the back' of the target, particularly around dawn.

(2) **Defence Saturation**. Compressing the attack provides the most obvious way to saturate enemy defences, but this must be tempered by the need to maintain adequate separation for both ASD and TFR reasons. Additionally, it is worth remembering that it is not possible to saturate defences that are providing barrage fire, ie unaimed with fixed line of fire.

AL2(MS)

(3) **Speed.** The highest speed commensurate with weapon aiming capability and delivery should be chosen. Use of reheat to achieve high speed over the target, or to make good a TOT bracket, is an option, but dry power should be selected before entering the likely engagement zones of close-in defences.

e. **Visual/ Non-Visual Conditions.** For "pre-planned " options, and indeed for any mission with adequate planning time, the worst case should be assumed and a plan made that is capable of execution in non-visual conditions. For LGB attacks, the cloudbase needs to be considered; as a rough guide, a 1000 ft base is required for a 20° release but mini-loft can be used with around 550 ft (Full parameters can be found in the LGB Performance Manual (D/DAGW/32/4/7/2) and Trial TAPSTER). Mini-loft profiles should be planned to be flown only in visual conditions because the aggressive recovery requires visual references.

f. **IMC Considerations.** Devising a simple plan to compress attacks in IMC conditions is not easy because of the ASD requirements of bombs or because of TFR intrusion. Some aspects of IMC attacks that deserve consideration are as follows:

(1) DMPIs that are sufficiently widely spaced allow pairs of aircraft to attack line abreast. For wartime, and provided ASD criteria are met, minimum lateral spacing of around 500 m could be used provided it was achieved with gently converging tracks. Conversely, this would restrict manoeuvring to avoid threats.

(2) For attacks using weapons that have very small self-damage footprints, such as JP233 or CBU, then tracks could be allowed to converge below 500 m provided elements were swept (but see TFR problems in next sub-para).

(3) The problems of TFR intrusion were investigated by the SAOEU and reported in Trial ROYDON. The recommendations of the trial were that the minimum trail distance over moderate terrain should be 20 sec or 15,000 ft, but that it could be reduced to 15 sec or 11,000 ft over gentle terrain, albeit with the attendant risk that if the leader pulls up significantly, then the trailing aircraft will be affected. The trial also found that with lateral spacing of 1,000 ft, then there was no interference from the aircraft ahead at any range and with 600 ft lateral spacing, interference was never a problem inside 3.5 nm. Therefore, close TF trail distances can be achieved provided that the trailing aircraft is not manoeuvred such that its nose comes to within 600 ft offset from the leader.

(4) The approach to the weapon release point should be studied to identify possible causes of inadvertent TF pull-up commands (ie major roads, railways, conurbations, airfield features such as hangars and leading aircraft pulling-up for trail loft attacks). Additionally,

crews should be prepared to counter TF pull-ups caused through enemy action (ie chaff or ECM). Albeit at unrealistic operational heights, Manual TF could be used to overcome this problem, but many areas would be suitable for Radar Height Hold use (presently only cleared over sea).

g. **Weapon Aiming Accuracy.** Trial SPARE concluded that the most accurate method of laydown weapon delivery was achieved by visually placing the bomb fall-line onto the aimpoint while remaining in Phase 1; known as Phase 1 1/2. A similar procedure was recommended for mini-loft attacks in the trials reports for Trial MAYCOCK and Trial TUMULT.

h. **Choice of Sensor.**

(1) **General.** Not only should the best available slant range/height sensor be used during an attack, but it is important that the second best should be available as a back-up. It is important to note that some back-up selections can cause difficulties as MC logic is not always obvious, particularly when cross-cockpit switching is required. The height sensor logic for a particular software standard is detailed in the TISMT Briefing Guide for the OFP and the Aircrew Manual Book 2. Trial TRADAR investigated how best to use height sensors and its findings are highlighted in the following paragraph and again at Section 6. Due to the flat nature of most weapon ranges and restrictions governing the use of Laser, Rad Alt is often used during training. However, complacency with using Rad Alt must be avoided, because operationally it will often be the least suitable height sensor as it is unsuitable over undulating terrain and, due to its false lock problems, it can easily spoil an attack.

(2) **Phase 1 Laydown Attacks.** For Phase 1 attacks the height sensors available are: Rad Alt, Baro/In, TF Elev, Rad Lock-On and Laser. Rad Alt is covered above. The Baro/In channel is only valid for one speed and for one atmospheric pressure and it requires accurate knowledge of target height AMSL. Trial TRADAR found that LRMTS provided the most accurate height sensor with the GMR second; it suggests that Baro/In should be used as a back-up to these even though the simplest method of keeping the channel updated is to plan height fixes, at attack speed, as close to the target as possible. Also, assuming the change in barometric pressure between the height finding area and target is known, a system correction can be made using the BAA procedure. In Trial WRENTHAM Part 3, TF Elev was found to be as accurate as Laser or AGR when functioning correctly. However, it has poor ECCM qualities and its mode of operation (it takes the highest elevation within the radar beam on its downscan) can sometimes give very large errors (up to 1 nm on the trial); thus currently, it is not cleared for hot/live drops. There is nothing forthcoming to change its mode of operation to gain a peacetime clearance but, as a last resort, it could give

good results if used against 'flat targets' in war. For laydown attacks, lock-on and laser ranging were investigated during the early parts of Trial WRENTHAM. Lock-on attacks overland require the aircraft to be flown higher than normal as radar detection range has to be increased to give the navigator time to acquire and lock to the target or offset. An additional problem with radar lock-on, is that the navigator cannot tell which part of the target the radar has locked to, because the radar picture is lost when locked-on, if the lock has wandered. Both of these points could give plan and/or height errors. Therefore, only small, radar discrete offsets or targets are suitable for lock-on attacks or fixes. On the trial, the laser performed well and proved to be the best option for overland use. The automatic deselection of laser when it reaches its gimbal limits, mentioned in the trial, has been overcome. It is advised that, for Phase 1 laydown attacks, crews should plan to use laser as the primary height sensor with Baro/In as the back-up.

(3) **Loft Attacks.** Although the same sensors mentioned above are available for Phase 1 loft, Trial WRENTHAM found different sensors most suitable. The trial proved the best height sensors to be: Baro/In for attacks over undulating terrain and Rad Alt for overwater attacks and for overland attacks, where the run-in is flat and the same height as the target. The trial also showed that:

(a) Laser was usable for mini-loft but the accuracy achieved was worse than that obtained from an accurate Baro/In channel.

(b) Weapons with gagged 117 tails landed 49 ft short of those with 114 tails.

(c) DOPP/SAHR mode gave very large overshoot errors and should not be attempted.

(d) The cross-wind errors are caused by the system not reacting quickly enough to changes in the wind during the pull-up. Until a method is found of 'predicting the wind', no automatic correction of the azimuth error is likely.

(4) **Phase 2/3 Attacks.** Slant range sensors provide the best aiming solutions for visual attacks and Trial WRENTHAM showed that laser and AGR gave similar results. It was suggested that laser should be the preferred sensor because, unlike AGR, it allows Baro/In to be the back-up. However, Trial WRENTHAM showed that during MTR attacks, the laser could lock to smoke, therefore giving false azimuth and/or height information; it is suggested that AGR should be used for ranging accuracy in smokey conditions. Should these systems fail or be unavailable then, because of the way the computer aiming solution is derived, it is essential that the direct height sensor used is accurate. With this in mind,

it is vital to update the Baro/In channel immediately before the attack with the aircraft settled straight and level and at the planned bombing speed. it is also possible to update the baro channel at cruise speed by applying TRADAR. If it is not possible to update the Baro/In channel, then a bomb short/long estimation may be useful to enable Rad Alt to be used (as a rough guide, 10 ft of height error gives 50 ft of forward throw error - 'pickle short on rising ground'). Height error may be apparent on offsets and it may be possible yo correct early by using BAA. If the error is known it can usually be corrected. Crews should also be aware of the range 'tromboning' problem that is caused by phase changing to Phase 2/3 too early and then using the PHC when the sight line to the target is very shallow or when terrain features intermittently obstruct the sight line to the target. Ballistic breakdown mentioned in Trial WRENTHAM has been overcome by a software 'patch'; the MC assumes that the aircraft is always at least 100 ft above the target, this causes erroneous aiming solutions should this height limitation be infringed.

WEAPON AIMING PROCEDURES

7.(C) **JP233 - General.** Weapon aiming procedures have already been outlined at Chapter 2 of this section. However, it is strongly recommended that the AWC OAE are consulted when planning major OCA options and time permits. Although it is possible to be sceptical of the scientific approach, these organizations can give valuable advice on how to make a raid plan more robust (for example see DOAO(G) Report 4/87 dated Sep 87 which compares alternative attack plans against two different airfields).

8.(C) **JP233 - Software.** There were several anomalies in the steering routine contained in SS7 108 UK which it is believed are retained in X903TISGEN. These anomalies, along with some considerations, should be addressed during planning.

a. **Centre Stick Aiming.** When centre stick aiming is used, the stick length entered should be half the actual length required. This will ensure that the HUD displays a valid end of stick position during the delivery; the CCIP will be advanced by half the stick length.

b. **Along' Attacks.** The following considerations apply to 'along' attacks.

(1) **Selection of Fixed Attack (F/A).** If F/A is selected outside 20 nm the aircraft will steer directly for the target position, but when the target range decreases to 20 nm, the aircraft will turn to achieve an intercept angle of 60° to the extended centreline of the runway or taxiway. However, if F/A is selected when within 20 nm of the target, then the aircraft will immediately take up the 60° cut steering; thus, if the aircraft is approaching on a track to intercept the extended centreline at less than 60°, then it will initially 'turn away' on selection of F/A.

(2) **Time/ Range to Target.** After F/A is selected, the target range displayed on the TV TAB and HSI is the range along heading to the point abeam the target; the TEL is also erroneous. Valid data is returned when the aircraft

has completed its turn and is pointing directly towards the target.

(3) **HSI Demanded Track.** HSI demanded track freezes on selection of F/A.

(4) **Track Capture.** As the aircraft approaches the extended centreline, it commences a TF turn towards the runway. When laterally displaced from the extended centreline by 507 m, an asymptotic rollout is commenced. The distance covered in the rollout is a function of turn radius modified by airspeed and wind.

c. **Across' Attacks.** Attacks made in the 'across' mode are conventional; the aircraft will fly a direct track towards the target whenever F/A is selected and the TEL functions correctly throughout. Therefore, F/A should be selected only when positioned on the required LOA.

9.(C) **JP233 - Attack Considerations.** Coordination of a combined 'along' and 'across' JP233 raid is complex and is aggravated by the anomalies outlined in para 8. Accordingly, some suggestions are made below to enable the steering/track capture laws to be used to advantage.

a. SAOEU trials suggest that aircraft attacking "along" track should be established on the LOA at least 3 nm before weapon release, with an additional allowance made for the asymptotic rollout to cater for strong winds.

b. The SAOEU designed template (see Annex C), used on a 1:50,000 scale map, defines the suggested track to be flown by an aircraft during an 'along' attack using the 60° offset approach steering law; it also gives the 'turn-on waypoint' which is essential for correct route timing. The aircraft is established on the LOA by 3 nm on completion of the asymptotic roll out.

c. Use of the template also facilitates coordination of 'along' and 'across' attack elements. For example, if a split of a pair of aircraft is made when they are on the 60° cut track and at 20 nm slant range to the target, then the resultant interval over the same DMPI would be around 22 sec at 480 kn. However, the split position may well have to be adjusted should the actual aiming point position selected give a decreased separation or should the 'across' attack track not give the required LOA. Ergo, safe separation for pairs of aircraft can be established. For larger formations, the most likely case, no simple attack plan that caters for all targets can be given although some pointers are offered as follows:

(1) The minimum separation over a DMPI should be at least 15 sec. Minimum separations are desirable for target defence saturation reasons but TF trail problems may well require greater intervals (see para 6f).

(2) Further pairs could attack using mirror image geometry, suitably separated on the same track or from the opposite direction. However, these options are likely to make the attack undesirably protracted.

(3) A 4-ship could attack such that the leading aircraft take the 'along' track(s) and following aircraft take timing/track delays to complete the 'across' attacks. While close

line-abreast attacks are not advised in IMC, approaching in swept pairs could appreciably reduce the time to complete the raid.

(4) It is probably easiest to build raids using elements of 4 aircraft, leaving windows for alternate TOTs.

(5) For raids against airfields where all approaches require similar LOAs, then the attacks could use geometry/timing along the lines of a CBU attack.

10.(C) **JP233 - Planning Sequence.** The following planning sequence is suggested:

a. Decide from which side of the airfield the 'along track' aircraft should approach and the most favourable LOA for the 'across' aircraft attacks.

b. Back plan from the respective runway threshold DMPI, using the template, to determine the 60° offset track (out to at least 20 nm) and the 'turn-on' waypoint to make good the LOA. The greatest accuracy possible should be strived for - use the best available runway heading and, for inclusion in the route, calculate the waypoint Lat/Long using the calculator.

c. Determine the split point (if applicable - see para 9c(3)). Ideally, this should be some 30-40 nm slant range from the target and allow a direct approach on LOA for 'across' attacking aircraft and space for 'along' ones to achieve the 60° cut track at least 20 nm. Such attack geometry will need to cater for the safe separation of all attacking aircraft and will need to be established/checked in the usual way.

d. On the 1:500,000 scale map, route plan to the split point and from the split point to the target using the normal TF turn strike-rule.

e. Choose and calculate offsets normally; however, the following additional points must be considered:

(1) Plan offsets as close to track as possible. Bear in mind that if they need to be worked whilst outside 20 nm, then the aircraft will have to be flown in 'heading hold' if steering complications are to be avoided.

(2) To take advantage of a possible late visual acquisition, final OAPs for all attacks should be selected as all-sensor since the target (especially a runway) itself may be difficult to detect on radar, particularly if debris from a previous attack has altered its radar signature.

(3) For 'across' attacks, the final OAP should be close to, and short of, the target to reduce aiming errors, as the DMPI is unlikely to be radar significant.

(4) For 'along' runway attacks, the final OAP should be no further than 4 nm.

(5) First-bomb aiming is automatically obtained for JP233 attacks.

11.(C) **JP233 - Execution.** Whilst the 'across' aircraft will fly a normal attack the crews of 'along' aircraft must ensure they carry out the following actions:

a. F/A is not selected outside 20 nm slant range from the target unless 'heading hold' is selected (until 20 nm or less from target).

b. The planned track, as determine using the template, is flown. If the aircraft is off this track the automatic steering will execute a 60° intercept to the LOA parallel but **not** coincident with the correct track for the pre-planned 'turn on' waypoint (see Annex D). The offsets may then be difficult to acquire and the timing will be incorrect.

c. TEL must be ignored after the selection of F/A until the aircraft is established on the LOA; planned groundspeed must be flown during this period.

d. The aiming offset should be accurately marked as soon as possible, particularly in azimuth. After working the final offset, the intention should be to go 'direct', if possible, on the end of the runway or taxiway because the accuracy of offset aiming may be insufficient to hit with the majority of the SG357s, particularly a taxiway. Experience shows that the runway/taxiway itself may well show very late; therefore, **do not move the marker on the CRPMD until certain that the aiming point is positively identified.** The aircraft should be flown in the latter stages of the attack parallel to the runway/taxiway with wings level.

12.(C) **Level Retard Attacks.** Level retard attacks should normally be planned at the maximum possible speed consistent with weapon delivery criteria, fuel available and the pilot's ability to remain at a very low height at high speed. If reheat is required to attain such high speeds, the acceleration should be planned outside the immediate target defences. Crews are advised to select laser ranging from Baro/IN for most Phase 1 attacks.

a. **Attacks in Non-Visual Conditions.** For Phase 1 attacks at 200 ft SCH features will show on radar significantly later than in day-to-day peacetime training. Crews may have to plan to fly higher than they would wish, particularly if they anticipate difficulties in seeing the final OAP.

b. **Attacks in Visual Conditions.** In visual conditions the laydown delivery from a straight approach enables the aircraft to be flown at operational low level; although a climb before weapon release to allow time for weapon fuzing might be necessary. Additionally, a gentle 'pop' manoeuvre may be necessary to acquire the target. Pilots should be able to remove visually across track aiming errors thus increasing the accuracy when compared to bombing in non-visual conditions. When planning, maximum use should be made of terrain screening to reduce unmask range. A turning approach to the target could be considered but target acquisition and aiming problems are increased. Even though aircraft height is usually increased and a planform may be presented to the defences, there are occasions when using valleys or good line features might justify a turning approach.

13.(C) **Shallow Dive Retard Attacks.** Shallow dive attacks with retard weapons may be the only option for reasons of terrain/weapon effects/target defences.

a. **Attacks in Non-Visual Conditions.** Dive attacks in non-visual conditions are not feasible.

b. **Attacks in Visual Conditions.** Where practicable the dive angle should be kept to the minimum that allows target acquisition and safe separation from high ground; ideally aircraft height should be kept below 1,000 ft. The run-in to the dive attack should be planned to give the earliest possible visual acquisition of the target. A straight-in approach with a pull-up followed by a bunt avoids the aircraft's planform being presented to the defences but may hide the target beneath the nose of the aircraft for a considerable time. The more usual entry is a pop-up and tip-in which presents a planform but should allow earlier target acquisition. However, if flown aggressively it presents any 'predicting' radar system with constantly changing elevation, azimuth, range and speed.

14.(C) **Low Loft Attacks.** Accurately aimed releases under 'g' should be possible in low loft up to about 45° of climb. Loft bombing in Tornado was addressed in Trials DAZE Stages 6 and 7, RUBELLITE and WRENTHAM. Releases at angles of above 40° should not be considered for an operational attack especially when heavyweight. Experience during Operation GRANBY highlighted the possibility of not achieving a release point solution from a low loft attack executed at high all up weights and in cold power, without delaying the pull-up sufficiently. Even when a release point solution is achieved under these conditions, the delivery aircraft is likely to be high, steep and slow when the last bomb is released, thus making the aircraft vulnerable to target defences and the recovery more difficult. In addition, the slow speed will reduce the difference between the velocity vectors of the bomb and aircraft which could increase the self-damage risk level to an unacceptable figure. Normally, releases should be planned for about 30° although LGBs will probably be released at about 20°. If maximum dry power is used instead of a maximum reheat, the pull-up should be delayed by 7 seconds. This is best achieved using the D--VFT setting. Operationally, an aircraft pulling-up in dry power from a very high speed entry will be less vulnerable to an IR missile threat and, of course, more difficult to detect with either the naked eye or an EO device. Therefore, when the tactical environment dictates and aircraft weight limits allow, low loft attacks should be planned to be flown without reheat but with an adequate delay to the pull-up point. Because of the long time of flight and bomb flight profile, crosswind has a significant effect on weapon aiming. However, except in conditions where the wind changes markedly with height (over 20 kn between run-in height and 3,500 ft) the MC release calculations compensate well. Improved results can be obtained in these conditions by using the methods outlined at Annex E, R to S allowing. The use of the forecast 3,500 ft wind is recommended so that crews can pre-plan the corrections and last minute 'guestimates' are avoided.

a. **Attacks in Non-Visual Conditions.** When planning crews should ensure that they are familiar with the complex switch sequences required when transitioning between TF flight and loft manoeuvres in non-visual conditions. These procedures were highlighted in Trial RUBELLITE and are detailed in Section 6.

b. **Attacks in Visual Conditions.** The planning of low-loft attacks in visual conditions should be straightforward.

c. **Loft Recoveries.** The apex for standard low-loft attacks using reheat would normally be above 5,000 ft and without reheat about 1,000 ft lower. Apex should be reached about 16 seconds after pull-up and the time spent above 200 ft AGL should be significantly less for attacks flown without reheat. The total time spent above 200 ft AGL can be reduced to less than 30 seconds for attacks with visually flown recoveries whilst recoveries in non-visual conditions requiring TF would probably take at least twice this time. To reduce exposure time, mission planning should be flexible when selecting escape headings for conventional loft recoveries; heading changes down to 60° should be considered when the tactical situation allows.

15.(C) **Mini-Loft Attacks.** Mini-loft attacks should be planned for visual conditions only. Normal attack speeds between 500 - 550 KCAS should be planned whenever possible; large weapon aiming errors due to the marked increase in release disturbance that occurs above this speed band, and below it the limited penetration potential of the bomb is not further reduced. The most successful planning procedure for mini-loft is to choose a high value DMPI such as a PBF and to choose an LOA almost at right angles to the target surface. The LOA should then be refined to give the best lead-in cues to acquire the aimpoint visually, finally radar offsets should be selected. The final OAP should not be closer to the target than the pull-up point and for sea level targets the pull-up point should be no closer than 11 secs Time-To-Go. Escape headings of 90°±30° should be chosen.

REVERSIONARY WEAPON AIMING

16.(R) Reversionary weapon aiming procedures should be planned. For attacks in visual conditions, standby sight settings can be used for all but loft attacks. For reversionary loft, quite accurate attacks could be achieved from a fighting battle formation position taking visual release cues from the bombs dropped from the other aircraft. Crews should also consider their actions in non-visual conditions with a degraded weapon aiming system. In IN Mode, Phase 1 and loft attacks should still be accurate. However, in Doppler/SAHR, Phase 1 attacks should be quite accurate providing the aircraft is kept straight and level just before and during release, but loft attacks will produce large along track errors because the doppler derived vertical velocities lag badly. IMC TF Dop/SAHR is not advisable and serious consideration should be given to aborting the mission.

INTEGRATED FORMATION ATTACK PLAN

17.(R) **Transition from Route Plan to Attack Plan.** The most difficult part of the attack plan will be the conversion from route formations to the attack. Speed changes to close up the spacing are costly on fuel and difficult to time and therefore it is preferable to use geometric methods to co-ordinate later aircraft over the target. Compromises will normally be necessary. The degree of compromise will depend upon many variables and will effect 'on and off target procedures and tactics. Formation size, formation type and types of delivery are important factors which can be adapted to provide defence saturation and yet maintain mutual support within pairs of aircraft 'on and off target.

18.(R) **Final Height Fix.** A final height fix should be taken as close as possible to weapon release. The procedure for height fixing is given in Chapter 6.

19.(R) **ASD Risk.** When a DMPI is attacked by more than one aircraft, those following will be at risk from fragments of the weapons dropped by preceding aircraft. They may also be at risk from ground debris thrown upwards but this risk cannot be quantified or computer modelled and thus it is not considered in ASD calculations. A wingman has three options:

a. To fly a close formation attack so as to be past the target before the ASD risk from the leader's weapons reaches 10^{-3}.

b. To fly a trail attack so as to reach the target after the high risk period from the leaders weapons has passed.

c. Using a common LOA, attack another DMPI either where there is Zero Risk or, as in a and b above, when the ASD risk is less than 10^{-3}.

20.(R) **Deconfliction of Tracks.** The planning principles for co-ordinating laydown and loft attacks normally includes near simultaneous bomb impacts and mutual support off target. Because the aircraft should be in close proximity to each other in the target area, attack tracks and escape tracks must be deconflicted during planning.

a. **Minimum Separation over Target.** The following times should be used when planning the minimum separation between aircraft attacking common DMPIs:

(1) JP 233 = 20secs

(2) 1,000 lb = 40 secs

(3) BL 755 = 15 secs

(4) 27 mm HE/APHE = N/A

Notes:

1. These times should be extended to cater for the worst case when the lead aircraft is late on TOT and the No 2 is early.

2. For loft attacks with same way recoveries, a pair of aircraft should be separated by 1 nm laterally and 10 secs in time.

b. **Attack Plan/Escape Plan.** Final LOAs will vary depending upon type of attack being flown, type of weapons being delivered, number of aircraft to be deconflicted, availability of offsets, target defences and target area terrain. Integrating mini-loft, low-loft and laydown attacks into one attack package should allow mutual support to be maintained as long as possible whilst permitting near simultaneous attacks to be made against common or different DMPIs. There could be occasions when the leading pair of aircraft are not the first to release their weapons. This will effect the escape plan. Mutual support can be achieved within the target area in many ways; two examples are shown in Figures 5-5-1 and 5-5-2. It has been amply demonstrated that turns off target increase exposure to AAA and SAM, when compared with low, straight and fast departures. Off-target TRPs should be used as en-route RVs.

c. **Alternative TOTs.** Aircraft unable to comply with briefed timing criteria will be required to leave the formation and achieve a briefed 'Alternate Time' behind the last aircraft. A fixed time, depending upon type of weapons carried, should be added to the individual's TOT or time at the pre-IP Waypoint. Table 5-5-1 shows how 'Alternate Times' can be calculated for a 4 aircraft laydown attack using 1,000 lb Retard bombs attacking the same DMPI. In the event of evasion, re-routeing or delay, the formation leader may, in a COMFREE environment, nominate a new TRP. The same principles should apply to any attack where the target is overflown. For loft attacks, time deconfliction is equally as important especially when common LOAs or escape tracks are used.

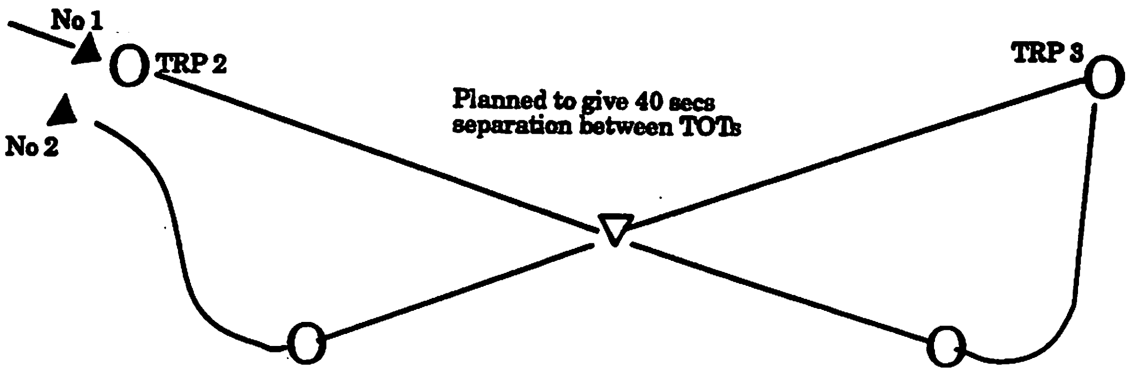


Figure 5-5-1(R) - Laydown Attack from 2-Aircraft Battle with 1,000 lb Bombs

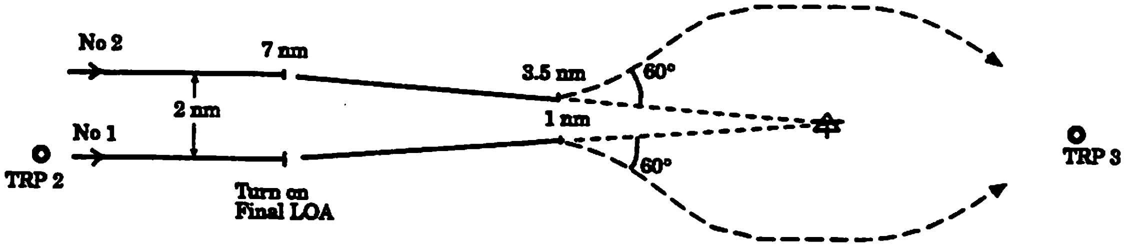


Figure 5-5-2(R) - Line Abreast Loft Attack

Ser (a)	Aircraft (b)	Original Times (c)	Alternate Time (d)
1	Lead	Lds TOT/Alt TOT	Original + 2 mins 40 secs
2	No 2	Lds TOT/Alt TOT +40 seconds	Original + 2 mins 40 secs
3	No 3	Lds TOT/Alt TOT +1 minute 20 secs	Original + 2 mins 40 secs
4	No 4	Lds TOT/Alt TOT +2 minutes	Original + 2 mins 40 secs

Table 5-5-1(R) - Calculation of 'AlternateTimes'

21.(S) **Close Formation Attacks.** One way to concentrate weapons on a target in the shortest possible time is to fly pairs of aircraft close together. A wingman has to position himself so that he is not endangered by the weapons of his leader; the exact position will depend on the weapon type, and self-damage characteristics of those weapons.

a. **JP 233.** (See ASD Manual Part 2 Section B). The ASD Manual contains data of the risk to the trail aircraft flying on the same LOA as the leader with a lateral separation of less than 300 m. The risk calculations assume that both warheads of one SG 357 munition will detonate before impact. Observations concerning ground debris are dependent on both release height and target surface. The best available information is that the debris column lasts for up to 10 seconds after each normal detonation of an SG 357 and is 40 m high and 26 m wide.

Note: The ASD risk to a Tornado overflying a target previously attacked by JP 233 does not exceed 10^{-3} for all passes above 30 m agl. Increased risk may occur with random detonations of SG 357s and HB 876s and this will be highest early in the period immediately after 'delivery plus 15 minutes'.

b. **Free-Fall Bombs.** (See ASD Manual Part 2 Section A3, A4 and A5). Zero risk data is given in the ASD manual for single and multi-aircraft Mini-Loft and Low Loft attacks for all operational configurations and a selection of target heights. Aircrew performing Mini-Loft attacks have less margin for error than Low-Loft.

c. **Retard Bombs.** (See ASD Manual Part 2 Section A2). The major source of risk to an aircraft in trail when the lead aircraft delivers retard bombs is from impact with, or ingestion of fragments from the exploding bombs. However, blast effects from the explosions can also contribute to aircraft damage. The ASD Manual considers both these sources of risk.

d. **BL 755.** (See ASD Manual Part 2 Section 2A). The ASD Manual gives risk information for a following aircraft assuming that the aircraft is damaged by the effects of the leader's weapons and not its own. The risk to a wingman from the BL 755 cluster weapon comes from fragmentation due to premature bomblet explosions and the 'furniture' (containers and container skins) from the leader's weapons. These items are best avoided by spacing wingmen laterally rather than longitudinally.

e. **Cannon.** (See ASD Manual Part 4). A leader and his wingman aiming at the same DMPI are, to all intents and purposes, equally at risk from debris resulting from strafing attacks. A wingman can avoid endangering his leader by spacing himself laterally and ensuring that their flightpaths do not get too close. Provided this is done there is no ASD reason why they should not concentrate their firepower by aiming at the same target at the same time.

22.(C) **Attacks in Trail.** The ASD Manual contains information on the minimum safe separation between aircraft when live weapons are used. (Wing SOPs should include an additional time over the minimum, of up to 10 seconds per aircraft quoted to allow for errors in Time Early/Late). A single DMPI is considered both for parallel and converging LOAs.

23.(R) **Attacks against Separate DMPIs.** (See ASD Manual Part 2 Section A2). The only weapon that requires ASD information for attacks against separate DMPIs is the 1,000 lb bomb. Crews should be aware that when using the same LOA irrespective of time, there is Zero Risk to a follow-on aircraft if the lateral separation between DMPIs exceeds 5,000 ft. Similarly, if the DMPIs are more than 3,000 ft apart, the risk level will be less than 10^{-3}.

OPERATIONAL DEGRADATION

24.(R) Academic weapon delivery accuracies will be degraded under operational conditions but it is not possible to quantify the exact extent. For other Ground Attack aircraft, delivery errors in range are thought likely to double, and errors in line to increase by 50%. Tornado accuracy could in general be better than this because blind bombing results have often been as good as visual results. Some factors responsible for operational degradation are discussed in the CTTO Tactical Handbook. However, there are two points worthy of note:

a. **Software Improvements.** Software improvements continue and the refinement of ballistic constants for both training and operational weapons is an on-going task.

b. **Training Scores.** Rad Alt has been the height sensor used for the majority of practice bombing. This is because of the flat nature of most of the RAF's bombing ranges. Operationally, although Rad Alt has its place other height sensors will probably be used and therefore operational results could well be markedly degraded when compared to those during training. Squadrons should, whenever possible, make the fullest use in training of the primary and reversionary height sensor combination most likely to be used operationally.

SUMMARY

25.(R) Target Area Planning can become an involved 'science' especially when large formations are considered and mixed weather is forecast. Most often, a successful plan is one that has been well rehearsed in peacetime and that follows the KIS principle - KEEP IT SIMPLE.

ANNEX A TO
SECTION 5, CHAPTER 5 OF
TORNADO GR1 TACTICS MANUAL

TORNADO TARGET AND OFFSET CALCULATIONS

1.(R) **Background.** Selection of Fix/Attack causes the Tornado Main Computer to assume that the Earth is flat. Offsets are therefore calculated using this flat-earth principle. This is to ease triangulation calculations using forward firing ranging sensors such as AGR and LRMTS. The further the offset is from the target, the greater the inaccuracy of the offset figures compared to the real world. It is for this reason that Tornado offsets are limited to 20nm from the target.

2.(R) **World-wide Operations.** It was originally envisaged that the Tornado would normally operate in Europe, and it was therefore optimised for such operations. Navigation calculations in the Tornado Main Computer are performed using a model of the earth based on the International Spheroid, on which most European mapping is modelled in the form of Eurodatum 1950 (ED50). Tornado operations, however, regularly take place outside the UK and Europe. A variety of different datums are used outside Europe, the main datum being WGS84 because it is most favoured by the Americans. Because the position of a point on the Earth calculated in WGS84, for example, has different lat/long co-ordinates from the same point on the Earth calculated in ED50, it is vital to work in the same datum throughout. In an ideal world, all fixpoints, targets and offsets would be calculated in ED50, because it is based on the International Spheroid, which the Tornado uses. Unfortunately, many countries use other mapping datums, and it is therefore necessary to perform datum shift calculations to ensure that co-ordinates are in the most suitable datum. It is particularly important to ensure that all fixpoints, targets and offsets use the same datum even if it is not possible to operate in ED50.

3.(R) **Methods of Calculation.** A number of methods exist to calculate target and offset positions. Targets and offsets are usually provided in Grid co-ordinates, (UTM Grid or British National Grid (BNG)), or in Lat/long. Both the grid-to-lat/long conversion algorithms and the spherical-to-flat earth conversion algorithms contain complex mathematical equations, and these tasks are therefore best performed by computer. A number of suitable programs and systems are available to perform such calculations. The current methods of target and offset calculations are as follows:

a. **CPGS.** Target and Offset figures can be calculated using the CPGS, but only in BNG or ED50. BNG can only be calculated using 6-figure numeric figures. Alphanumeric BNG figures (ie SU 09844 45323) are not supported, and therefore the British Isles are not covered at the Northern extremities. In addition, the CPGS cannot calculate any UTM positions in the Southern Hemisphere. The CPGS is therefore effectively limited to operations in Europe.

b. **Casio Hand-held Computers.** A number of Casio hand-held computers are available on squadrons. Areas of coverage vary from machine to machine but, at best, coverage is limited to numeric BNG, UTM and lat/long inputs in Europe or North America (NAD27). No datum shift facility exists with these machines, nor are they capable of operation in the Southern Hemisphere.

c. **Tornado Offset Program.** Tornado Offset Program is a PC-based program written by a Tornado pilot, and is in widespread use among front-line squadrons. This program will calculate target and offset positions using a wide number of spheroids. It does not, however, permit datum shift calculations or alphanumeric UTM or BNG positions.

d. **MADTRAN Datum Transformation Program.** MADTRAN is a program produced by the American Defence Mapping Agency (DMA) after the Gulf War. It produces accurate conversion of UTM to lat/long in virtually all known datums, and will convert these figures into or out of WGS84 as required. It does not however recognise BNG inputs of any kind, and cannot calculate offsets. Although useful, it can only be used for Tornado planning when used with other offset calculating programs.

e. **TORCALC.** TORCALC is a PC-based program written by a Tornado navigator, and is available through TISMT. It has been officially checked for accuracy by Mil Survey, and is in widespread use on front-line squadrons. This program calculates targets and offsets in a wide variety of spheroids, and supports alphanumeric and numeric BNG and UTM inputs in addition to lat/long. It also does reverse calculations of lat/long to BNG or UTM. It can perform datum shift calculations into and out of WGS84 for all current operational areas of interest, and is capable of operation in the Southern Hemisphere.

ANNEX B TO
SECTION 5, CHAPTER 5 OF
TORNADO GR1 TACTICS MANUAL

DEFICIENCIES IN COCKPIT ERGONOMICS - TRIAL RUBIAN

1.(R) Throughout Trial RUBIAN, a number of Human Factor deficiencies emerged. These problems were sometimes referred to in the post-flight notes by the aircrew and some were identified from the voice tapes. In the main, the problems were caused by poor instrument design, cockpit lighting or layout. The most frequently mentioned problems were:

a. The intrusive nature of the audio warnings which were both unnecessarily distracting and prevented communication between the front and rear cockpits - often at critical moments.

b. The design of the E-Scope display which is difficult to interpret due to the horizontal logarithmic range scale and the vertical TFR angle scale.

c. Difficulty in making AFDS control panel selections on the left console.

d. Inadequate lighting adjustment on the navigator's Combined Radar and Projected Map Display and the pilot's Repeater Projected Map Display.

e. The design of the TF warning system does not allow rapid diagnosis of TF malfunctions and requires close co-operation between the front and rear cockpits.

f. Lateral head movement is required before the pilot can see the 4-6 nm portion of the E-Scope.

g. The requirement to hold the fuel gauge selector button depressed with the right hand until the gauge reading stabilises before the wing or under wing/fuselage tank contents can be ascertained.

h. HUD design eye level causes some pilots to adopt an uncomfortable seating position.

i. Few instruments are orientated directly towards the pilot's eye; for example, the datum track figures, top right of the HSI are difficult to see from a normal eye position.

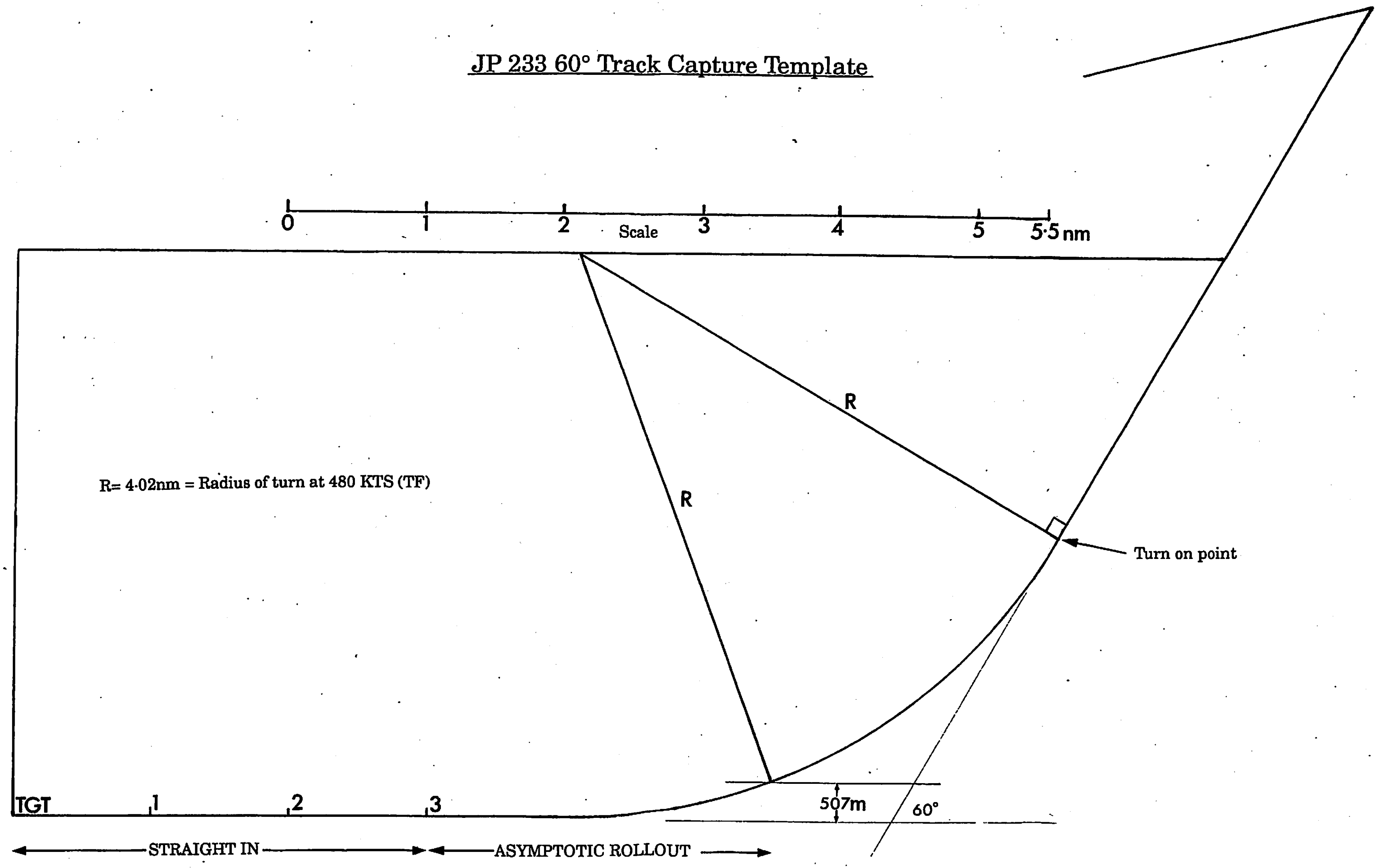
j. The position of the anti-collision lights causes glare when flying at night and, although it is recognised that they would not be used in war, the disruption to peacetime training is undesirable.

k. Possibility of confusing the Rad Alt ON/OFF switch with the bug adjustment knob - leading to the possibility of turning the Rad Alt to OFF when a change in set-height is required. (Re-set time is at least 30 seconds).

2.(R) The presence of these Human Factor design problems was considered to have contributed very significantly to aircrew workload particularly during critical or demanding tasks.

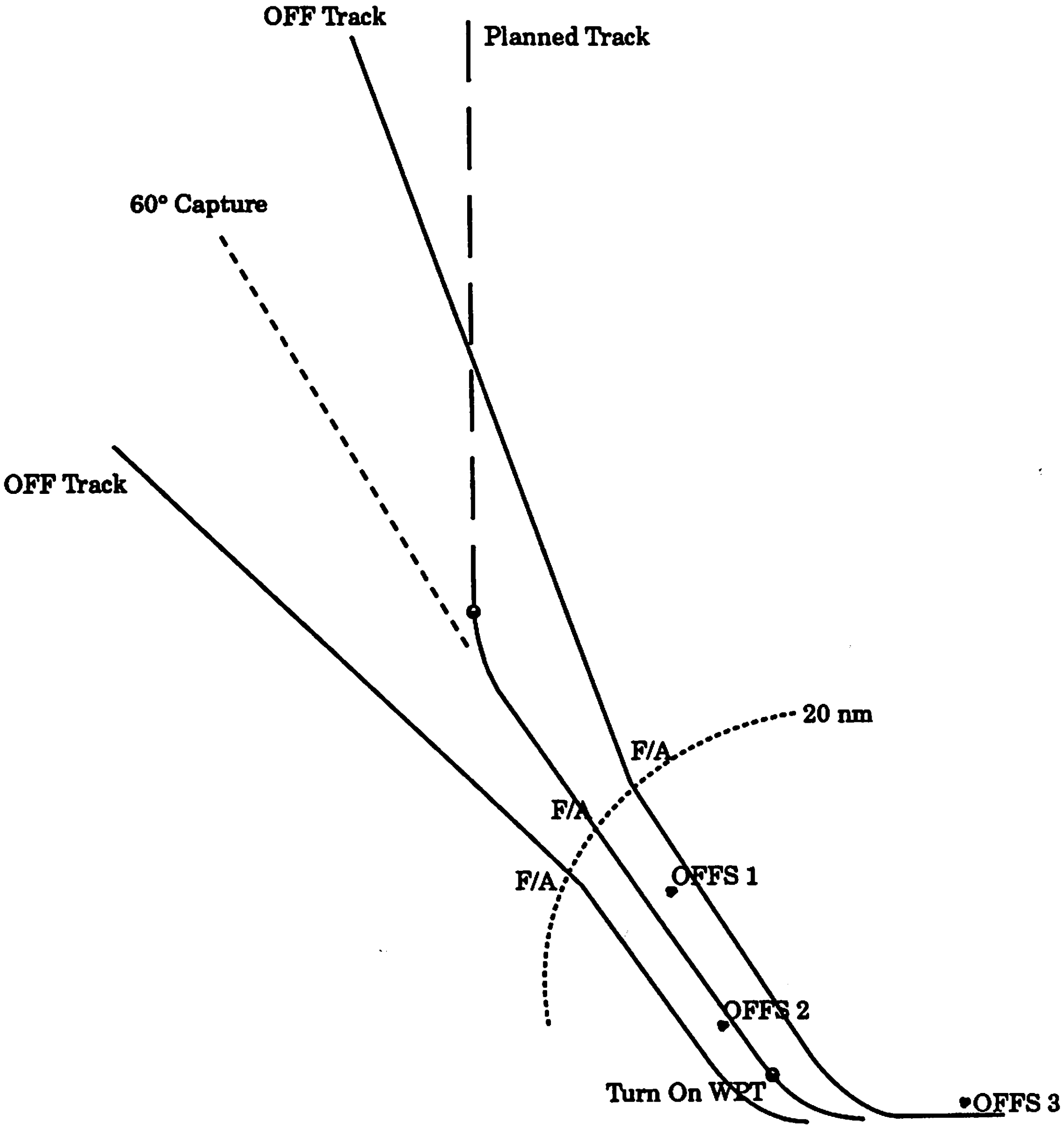
INTENTIONALLY BLANK

JP 233 60° Track Capture Template



INTENTIONALLY BLANK

JP 233 - TRACKING ERRORS



INTENTIONALLY BLANK

ANNEX E TO
SECTION 5, CHAPTER 5 OF
TORNADO GR1 TACTICS MANUAL

FOUR METHODS OF REMOVING WIND EFFECT IN LOFT

1.(R) There are four methods available for the removal of wind effect. Table 5-5E-1 below lists them and gives their relevant disadvantages.

SER (a)	METHOD (b)	DISADVANTAGES (c)
1	USE OFFSET TO GIVE FALSE TARGET POSITION (5 ft/kn)	1. Wastes an offset. 2. Complicated to calculate - must be done using forecast winds before flight - late changes impractical.
2	SELECT MOVING TARGET ONCE IN THE PULL-UP (1 kn of target motion for every 10 kn of crosswind).	1. Any target annotated with a course and speed is assumed to be at sea level. 2. Only accurate over flat terrain using Rad Alt. If target significantly above sea level, BARO/IN will induce large range errors. 3. 'TGT' on TV Tabs not available once target is annotated with a course and speed, it is only available under 'MVT' key.
3	MOVE 'ACTIVE RADAR MARKER' INTO WIND (5 ft/kn)	1. Judging accurate offset distances difficult on marker. Note: on 2 nm scale, one arm of the cross equates to just over 400 ft.
4	MANUAL WIND OVERWRITTEN ON TV TAB	1. Can enter a wind for intermediate height ie 3,500 ft wind if difference from low level wind is significant.

Table 5-5E-1 (R) - Wind Effect Removal Methods - Disadvantages

2.(R) On most occasions the wind difference will be less than 20 kn so the required correction will be less than 100 ft. Therefore, in practice the error is small enough to be ignored.

3.(R) Should the crosswind difference between low level and 3,500 ft be over 20 kn the most appropriate method for crews to use will vary depending upon the circumstances and target characteristics.

4.(R) SS7-0107 should simplify loft wind allowance procedures.

INTENTIONALLY BLANK

CHAPTER 6 - ROUTE PLANNING

INTRODUCTION

1.(R) The requirements of a route plan for a Tornado mission will be determined largely by the conditions in which it will be flown - visual or non-visual. This chapter will predominantly discuss planning procedures for non-visual sorties; although visual planning is not ignored.

NON-VISUAL PLANNING

2.(R) Non-visual planning will have to be completed for night/IMC missions and for missions where mixed weather is forecast. For a singleton aircraft, non-visual planning is simple, but planning for formations is laborious and complicated, requiring conscientious attention to detail and teamwork from all members of the formation. In particular, for co-ordinated formation attacks, accurate timing throughout the mission will be of paramount importance and much of this section will address this point.

3.(R) **Choice of Formation.** A number of factors will affect the decision on the size and type of formation, such as time available over the target, extent of damage required and range of the target. Although for mixed weather and non-visual missions the planning procedures will be similar, the choice of formation may be different. Whereas for mixed weather, formations such as Card and Goose have some advantages, for non-visual conditions the smaller more manageable formation of the Battle Pair may be more suitable. The decision on formation type must however remain with the squadrons and the remainder of these route planning considerations apply equally to both mixed weather and non-visual planning.

4.(C) **SUPPLAN MIKE.** All conventional air operations are likely to be planned in accordance with SUPPLAN MIKE or an equivalent document. Therefore, SUPPLAN MIKE procedures are considered for the rest of this section. The limited number of routes available to a formation during the time of the mission could impose severe penalties in terms of fuel required and the time flexibility available to meet the TOT. Also the width of the Transit Corridors (TC) and Low Level Transit Routes (LLTR) must be considered when planning the width of formations to be flown as it may be necessary to fly those portions of the mission subject to SUPPLAN MIKE in line astern, thus avoiding the danger of aircraft being forced out of the relative safety of the TC or LLTR by having to maintain a parallel track to the element leader. Since SUPPLAN MIKE type routeing has such a strong impact on the remainder of route planning, it must be a primary consideration.

5.(R) **Recovery Procedures.** A further 'non-negotiable' planning consideration is the recovery procedure at the intended landing airfield. The procedure may commence some distance from the airfield, requiring a 'straight-in' low speed approach. To achieve the necessary separation between aircraft for landing, it may be necessary to plan a speed or manoeuvre split some distance from the recovery datum. (**Note:** To split a Card formation at 420 kn into singletons at 3 nm spacing and 360 kn by use of speed split alone would take 8 mins and the leader would travel 66 nm).

6.(C) **Route Selection.** When the SUPPLAN MIKE routeing, recovery procedures and target area planning (including split points and RV points) have been completed, the remainder of the route can be selected. The following basic principles should be considered.

a. Avoid overflying towns, main junctions, large bridges, industrial complexes, railyards, airfields, radio masts or any feature that is likely to be defended. Static defences - such as Early Warning Sites - or known CAP positions could be entered in mission data as intelligence points. Crews should be aware that the performance envelopes quoted for missile and gun systems are normally for an ideal site under perfect conditions. These figures can be degraded by hilly or wooded terrain, bad weather and poor light conditions. If terrain screening data is available, it should be used.

b. Avoid flying along major lines of communication.

c. Ground features need not be selected as turning points provided that the selected track will pass close to fix points.

d. If possible FEBA penetration should be made at right angles, very high speed and ultra low level to reduce exposure time. Furthermore, where possible, the area selected for FEBA penetration should be chosen to have the least suitable terrain for mobile defence systems.

e. Lines of pylons should be crossed at shallow angles to ensure that at least one pylon falls within the beam of the TFR.

f. Turns into steeply rising ground should be avoided because the total 'g' required for the turn and the climb may exceed the authority of the AFDS, causing it to decrease the bank, and increase the radius of turn.

g. The first turn at low level in TF should be simple - over flat ground and less than 90°. This allows the crew to build confidence in the system and, as shown by Trial RUBIAN, effectively reduces crew workload at this stage of the mission.

Where formations are planned which require parallel tracks all these considerations must be taken into account for both tracks, making route selection a complicated, time consuming operation.

7.(C) **Fixpoint Selection.** The selection of good fixpoints is an essential part of mission planning. For Lo-Lo missions there will be neither the time nor the need for many fixpoints, whilst for the Hi-Lo-Hi missions, there may be few fixpoints available for part of the high level routeing. When established at low level both types of mission should require a maximum of two plan fixes before the target if the navigational equipment is serviceable. The first fix would be to confirm that the Main Computer (MC) present position (PP) is being accurately maintained, and the second fix should be a 'pre-target fix', approximately 20 nm before the target, to correct any small errors prior to entering the attack sequence. It may however be prudent to plan two further fixes. The first of these should be in a 'quiet' area if the FLOT has been crossed and used if the check fix showed the navigational equipment to be drifting at an abnormally high rate, and the second should simply be an alternative pre-target fix in the event of the primary pre-target fix not being identifiable. Where parallel tracks are planned the utility of the fix point must be checked for both tracks, taking into account terrain. Where necessary each track may require individual fixpoints.

8.(C) **Height Fixing.** An accurate height sensor is an essential element in a successful attack. Where possible, a slant range sensor such as laser should be used with Baro/IN as the reversionary height sensor though, for loft attacks, Baro/IN would normally be the prime height sensor. It is thus very important for the Baro/IN height channel to be corrected as near to the target as possible, and a suitable height fix should be planned at about 20 nm from the target. The height fix may be taken independently, using the Rad Alt, or as part of a plan fix using a suitable height sensor: in either case, the fix should be taken with the aircraft stabilised straight and level at attack speed in the attack configuration. Problems with taking a Rad Alt height fix are many and varied, they include finding a suitable flat area of land, or if an inland water feature is used, the accurate height AMSL of the surface of that water. Suitable areas would probably need to be larger than a circle of radius 0.5 nm (it has been suggested that a height fix catalogue would be advantageous to identify suitable height fixing areas, in the same way that the existing plan fix catalogues are used). The Best Available Altitude (BAA) facility was introduced to allow inspection, and alteration of Baro/IN height, but care must be taken with its use to avoid corrupting the height channel. Results from Trial TRADAR indicated that there was a linear relationship between changes in the height channel and indicated airspeed (IAS). Therefore, while still on the ground the system height can be adjusted for any given IAS. To make the system accurate for 420 kn, either 88 ft can be added to the initial pan height and a normal height fix taken or 88 ft added to the BAA value. For speeds above 420 kn, values of +40 ft per 100 kn above 420 kn can be added. While TRADAR values should be set on the pan for the planned transit speed, crews should continue to plan suitable height fixes and monitor the system height; errors peculiar to an individual airframe and errors caused by barometric pressure changes should be removed. The final pre-target height fix, corrected where appropriate for the change in barometric pressure between the height finding area and target, is still vital to a successful weapon delivery.

9.(R) **Timing.** Timing is of paramount importance in the co-ordination of a formation of aircraft in non-visual conditions and much care must be taken in its calculation for mission planning. The 'Time Line' principle should be used and a number of important factors have to be considered:

a. **Datum.** The datum time should always be 'Real Time' and not elapsed time.

b. **Turns.** All turns should be planned as TF turns in accordance with the MC calculations. If the turns are flown visually, (eg in mixed weather) the following rules of thumb can be used to maintain timing when turning at 60° angle of bank through the number of degrees shown below:

(1) Less than 30° - Turn at the turning point.

(2) 30° - 60° - Delay the turn by 5 secs.

(3) 60° - 120° - Delay the turn by 10 secs.

(4) More than 120° - Fly TF turns.

c. **Leg Speed.** Only one leg speed can be used for each leg of the route. If an acceleration is required a further short leg should be planned to be flown at a speed slightly lower than that required to allow for the acceleration time. Ideally, accelerations should be made in conjunction with existing waypoints.

d. **Leg Length.** Practically, to remain on time, leg lengths should be no longer than 50 nm as at greater distances the TEL becomes very sensitive to minor speed changes.

e. **Timing Reference Points (TRP).** TRPs are required to maintain formation positions and to achieve accurate TOTs with sufficient separation between aircraft overflying the same DMPI. For example, TRP 1 might be the first split point ie the last common point for all aircraft; TRP 2 could be the TOT for each individual aircraft and TRP 3 the rejoin point post-target. Depending on the type and size of formation, TRPs between individual or pairs of aircraft could be separated by 20 to 40 secs, only the leaders time would be briefed. As the mission progresses, each crew would use the relevant TRP for that stage of the mission to maintain the time-line. It should be noted that whilst the TRP for the No 4 in the formation may be one minute behind the leader when flying the route (3 x 20 sec) it may be necessary to extend this separation to 2 minutes (3 x 40 sec) over the DMPI, and planning should take this into account.

f. **Use of CPGS.** To confirm timings and to ensure that all crews have a print-out of TRPs and real times at each waypoint, the CPGS should be used.

g. **Alternate TOTs.** Alternate TOT times must be planned to account for missed attacks by members of the formation (see Chapter 5).

h. **Parallel Tracks.** When planning timing for parallel tracks it will be necessary, when planning manually, to adjust turning points to maintain separation on succeeding legs; this might also require an alteration in planned groundspeed to maintain line abreast formation position (see Figure 5-6-1). In this situation the correct turning radius must be used to ensure parallel tracks are maintained. For turns of less than 20° the difference in distance and ground speed can be ignored.

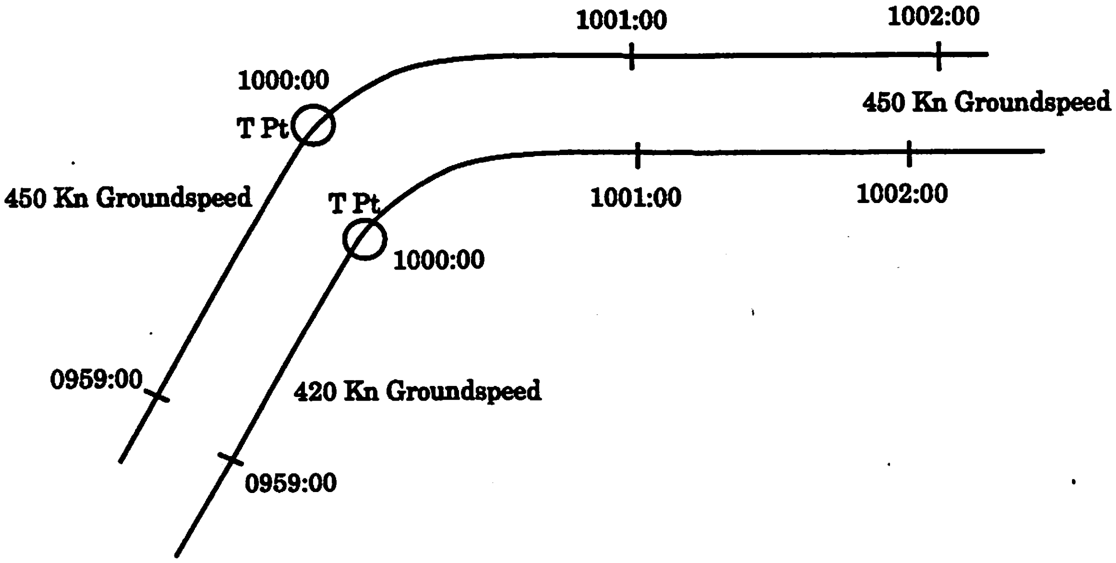


Figure 5-6-1(R) - Turns - Parallel Track

i. **Time Check.** Since timing is important for deconfliction a time check at some stage during briefing is essential. If a mission is told to 'Stand On' for any length of time however, it is important that a further time check is taken to ensure synchronization before take-off.

Finally, when using TRPs and the 'time line', crews should understand that to be in the correct position relative to a formation the aircraft must be on planned speed and on time, any other combination is WRONG.

10.(C) **Fuel Planning.** When the route has been drawn and the speed for each leg annotated, the fuel plan can be made. The planned landing fuel is 600 kg and any fuel over this represents combat allowance which should be a minimum of 700 kg for STC units and 10% of fuel mass for RAFG units. The minimum fuel required for recovery at any stage should be calculated, and to allow for fuel tank damage, alternative airfields closer to the FLOT should be highlighted. Where necessary the leader may wish to nominate fuel states for Bingo calls (these may be 'silent') and Chicken fuel. Trial TUNA, which was flown by the TOEU, showed that there was no practical difference in the fuel flow rates using either automatic or manual throttle control.

11.(R) **Losers.** The best plans are regularly upset if aircraft become unserviceable. Simple fall-back plans are essential to cope with aircraft which fail to get airborne, have major airborne emergencies or are shot down. With very large formations and complex attacks, an individual plan will have to be worked out at the time. For 4-aircraft formations however there should be a 'losers' plan which may entail alterations to attack tracks and TRPs. It is impossible in this Manual to stipulate courses of action in any particular circumstance but squadron SOPs should exist based on the types of formation usually flown.

12.(R) **Route Study.** When the route has been drawn and finalised it should be studied and the likely response of the auto-TF system anticipated, those points at which significant climbs or descents are expected should be marked on the map. During the route study, problem areas for the TF radar should be annotated so that the GMR can be used to monitor the TFR; annotation could be in the form of intelligence points which could be entered into the computer. In addition any areas where the TF system may fly lower than the selected SCH but above the 70% low altitude warning height should be annotated, eg over areas of sand dunes, or gentle slopes that may be snow covered. Additionally, pylons and obstructions should be highlighted so that they can be anticipated in the event of having to use E-Scope TF.

13.(C) **Reversionary Modes/ Calculation of Safety Heights.** To ensure the success of the mission after any failure which precludes all forms of TF flight, safety heights or minimum en-route altitudes (MEA) should be calculated for complete legs or portions of legs where there is a significant change. Escape routes or legs may be planned should the crew have to avoid the target area following equipment failures. If TF is not possible then two modes of operation remain:

a. **GMR Terrain Avoidance (TA) Mode.** Little information is available on GMR TA Mode, thus more operating experience will be required before realistic operating heights can be established. (Currently, it is only cleared for above 1,000 ft in the Release to Service). It is however an option which should not be overlooked when attempting to remain at low level in night/IMC conditions.

b. **Safety Heights.** With any navigation system it is possible to plan to fly at some predetermined height above an obstacle within a distance from planned track dependent upon the confidence in the navigation system. Tornado's main mode has proved very accurate and crews should be able to plan safely to avoid only obstacles within 1.5 nm of planned track. The MEA chosen should reflect a balance between the increased risk of hitting obstacles if too low a height is selected, and the increased risk from opposing air defences if the height selected is too high. As the opposing defences almost certainly require radar information in these circumstances, the selection of two MEAs is well worth considering, though this refinement may only be feasible for pre-planned missions where time is available to consider all the relevant factors during planning. A higher MEA could be flown until a RHWR threat warning is received when the aircraft should be descended to a lower MEA to reduce the risk from defences. Escape legs should be planned to rejoin the homebound track in case the crew decide not to continue to the target. In this situation, the forecast QNH assumes great importance, and although the number of QNHs required depends on the weather pattern, variations as small as one mb (30 ft) should be taken into account. Crews should consider using the radar altimeter to read off the height above flat terrain or water features of known height AMSL and combine that information to update the barometric altimeter. Aircrews should note that levels of reservoirs, lakes etc vary with seasonal changes and consumer demands.

VISUAL PLANNING

14.(C) The occasions when a purely visual sortie can be planned are very limited, and it would be prudent always to plan for mixed weather. The two major advantages of visual planning are simplicity and speed. The greatest saving of time and effort results from the need to plan just one single sortie track until the split point for the attack, although other savings can be made throughout the planning cycle. Many planning procedures will mirror those for non-visual planning; some differences are discussed in the following paragraphs.

15.(R) **Choice of Formation.** The formation leader is given much greater flexibility in the choice of formations. Where possible formations should be chosen to give maximum cross-cover for visual lookout whilst maintaining an ability to provide mutual defence with AIM-9, eg Card, ~~or~~ Escort. OR GOOSE.

16.(R) **Route Selection.** When planning the route for visual sorties more use can be made of terrain screening. Small valleys or rising ground which may have been insignificant to TF flight may be utilized to maximum advantage in visual conditions. Solid ground between the aircraft and a threat radar is a better 'jammer' than any combination of ECM pod and chaff.

17.(C) **Fixpoint Selection.** Fixpoints are selected using similar criteria to those used in the selection of OAPs discussed in Chapter 5. Visual fixpoints can be chosen provided they are expected to fall within the HUD field of view (FOV), however, whilst these have the advantage of maintaining radar silence with less chance of detection by passive systems such as RAMONA, there is the risk that by being off track, or off heading the fixpoint will fall outside the HUD FOV. Choosing all sensor fixes is the ideal compromise. Also, fixpoints should be chosen and designated so that no more than half the formation is simultaneously engaged in fixing, allowing the remainder of the formation to maintain the visual look-out (see also para 7).

18.(R) **Height Fixing.** The ability of crews to see flat ground or water features will allow height fix areas to be

AL 2 (MS)

smaller. Again however, if OTF height fixing is used, the fixpoints must be on the track of each member of the formation so that formation geometry does not have to change simply to overfly a set point (see also para 8).

19.(R) **Timing.** Timing is less important for visual sorties because it is not the datum on which aircraft separation en route is based; its importance lies only in achieving TOTs and safe separation over the target for co-ordinated attacks. Alternate TOT times will still be important however, as will accurate timings for splits, TOTs and RVs post target (see also para 9).

CONCLUSION

20.(R) A good plan is an essential prelude to a successful attack mission. Planning time is usually short, so first rate leadership and organization are as important in the planning room as in the air. The sequence generally starts with the target, and choice of attack direction with offsets. The route to the target planned with regard to the latest intelligence information can then be selected to achieve the optimum en-route protection and required track separation at the TRPs. The sequence is completed with a formation briefing at which all members of the formation are made fully aware of all aspects of the planned mission and their roles in it.

INTENTIONALLY BLANK

CHAPTER 7 - ATTACK MISSION BRIEFING GUIDE

INTRODUCTION

1.(U) Chapters 5 and 6 of this Section have discussed considerations and procedures for planning attack missions. The aim of this Chapter is to summarize mission planning by giving suggested examples of an attack planning sequence, an attack planning guide for a four aircraft formation, and a briefing guide.

ATTACK PLANNING SEQUENCE

2.(U) An attack planning sequence is shown at Annex A. The sequence takes no account of peacetime planning requirements.

ATTACK PLANNING GUIDE

3.(R) A suggested attack planning guide is at Annex B. The Annex assumes that No 2 is the deputy leader and therefore takes a major role in planning. The responsibilities may be altered if No 3 is deputy lead. If a pairs mission is planned those duties allocated to Nos 3 and 4 in Annex B can be carried out by spare crews if available, or mission planning personnel, or by the No 2 crew at the times when it is shown as duplicating the duties of the lead crew.

ATTACK MISSION BRIEFING GUIDE

4.(R) A suggested attack mission briefing guide is at Annex C. The guide is very flexible in that many of the items covered may have been briefed previously by Int or Met personnel. Also some of the items may be adequately covered in SOPs, however, care must be taken that SOPs are fully understood as the success of a mission depends largely on the success of a brief; and a brief is successful only if, at its conclusion, all the crews are fully aware of their roles in the mission at all stages of its execution.

INTENTIONALLY BLANK

ANNEX A TO
SECTION 5, CHAPTER 7 of
TORNADO GR1 TACTICS MANUAL

ATTACK PLANNING SEQUENCE

Serial	Task
1	Establish whether TOT can be met and if AAR is required.
2	Decide on weapons load and settings(if not covered in ATM).
3	Pass weapons information to Ops/Eng.
4.	Plan Supplan MIKE routeing and recovery procedures.
5	Decide formation, decide and plot optimum attack direction(s), decide weapon delivery mode.
6	Decide final LOAs, attack sequence and offsets. Decide off-target procedures. Calculate offsets.
7	Select final plan fix/height fix points.
8	Assemble and photocopy/glue maps.
9	Prepare target maps. Calculate standby weapon aiming settings.
10	Complete route plan with times, speeds, TRPs, fix points, TFR obstacles, deconfliction, fuel, recovery diversion.
11	Prepare cassettes.
12	Decide Bingo/Chicken Fuels.
13	Identify TFR safety heights (MEAs).
14	Confirm IFF settings, procedural altitudes, authentication.
15	Prepare briefing material.
16	Brief the sortie.
17	Initiate aircraft preparation (INS warm-up etc).
18	Final Int/NBC state update.
19	Complete walk-out procedures - empty pockets/collect pistol/F189.

INTENTIONALLY BLANK

1P	1N	2P	2N	3P	3N	4P	4N
Check ATM and whether TOT can be met. Check Weapons load, SUPPLAN MIKE, Met, Recovery Procedures. Estimate Fuel and AAR requirements. Establish Brief, Walk, and approx T/O times. Tell Ops, Engineers, Nos 3 & 4				Obtain Tgt and Route Intell Tell 1P & 1N	Check ATM for special procedures Tell 1P & 1N	Prepare viewfoils for aircraft configuration & T/O calcs	Collect AMSC 670, AMSC 601, IFF codes Note FLOT & FSCL Tell 1N
Decide formation. Prepare SAP map. Select DMPIs (if necessary). Select offsets, split points & attack sequence.		Prepare Master SAP map	Obtain most accurate Posn time will allow of DMPI and offsets.	Co-ordinate AAR. Assemble SAP maps.	With 2N obtain DMPI and Offset data.	Collect and prepare Tactics viewfoils. Prepare (with EWO if possible) Threat and EW viewfoils.	
Calculate IP - Tgt times for Formation	Choose TCs and LLTRs select fix pts, Ht fixes & Rte	Calculate IP - Tgt times for Formation.	Calculate Tgt & offset Ht data for Formation	Glue and copy SAP maps	Calculate Offset data	Glue and copy SAP maps	Put TCs and LLTRs into route on CPGS.
Check Tgt viewfoils. Assemble viewfoils	Plan leg speeds CPGS PLAN Format Check speeds & times Allocate TRPs GATE times.	Calculate S/by sight settings Check fuels.	Plan leg speeds CPGS PLAN Format Check speeds and times.	Calculate S/by sight settings. Study SAP	Draw routes. Prepare Briefing room.	Check MISREP & IFREP requirements. Check alternate airfields	Put route on CPGS. Draw routes.
Study SAP	EMCON/ COMPLAN Study Route	Study SAP	Study route Highlight Obstructions	Coffee/tea	Prepare 4 x Route & PLAN printouts & cassettes.	Study SAP	Highlight Obst Calculate MEAs.

Notes:
1. In peacetime NOTAMS and CAMPs must be checked, Low level bookings made and CA48/Warn out.
2. For monitoring purposes Sqn Ops should be informed when planning is complete.

Table 5-7B-1 (R) - Attack Planning Guide

INTENTIONALLY BLANK

ANNEX C TO
SECTION 5, CHAPTER 7 of
TORNADO GR1 TACTICS MANUAL

ATTACK MISSION BRIEFING GUIDE

1. AIM:

Outline of task from Air Task Form
Target - type, location, weapon choice
Photo/Int coverage

2. INTELLIGENCE:

GCI/EW boundaries and cover
SAM Sites
Fighter CAP locations/Wingspan/Performance
AAA concentrations
Fire Support Co-ordination Line/FLOT
Friendly forces
BDZ and SUPPLAN MIKE routeing

3. WEATHER:

General Situation/QNHs
Base
Route
Target
Diversions

4. DOMESTICS:

- Composition:
  - Callsign, section leader, deputy leader, losers
- Aircraft, HAS
- Weapon loads, implications of different loads, restrictions
- Fuel loads, calls and management
- Communications:
  - Electronic Emission Control (EMCON) Policy
  - IFF settings/switch on lines
  - TACAN channels
  - Authentication
- Timings:
  - Walk, start, taxi, take-off, TRP, TOT, GATE
  - IFF times, recovery slot

5. DISPERSAL:

Pre-start procedures, NBC state, Air Raid
Post-start procedures

6. TAXI:

Intervals
Possible Cratering

7. **LINE-UP:**

8. **TAKE-OFF AND DEPARTURE:**

Rotate, Unstick, V Stop, Safety

9. **FORMATIONS:**

Join-up
Route
Lookout and Reporting
    Transformation from VMC to IMC

10. **EW:**

RWE/RHWR Settings
Skyshadow Settings
BOZ Chaff & IRD Program(s)

11. **PENETRATION:**

Fixpoints
Ht Fixes
Map Check - route, hdgs, times, MEAs, obstructions, pylons
Defended areas
Tactics if intercepted
RHWR, ECM use

12. **TARGET AREA:**

Weapon Allocation
OAPs
Height Sensor options]
IP to PUP/Tgt (if visual)
Formations
Attack Intervals/Timing
Aim Points/Acquisition
Attack directions
Target height/QNH/Terrain
Commit/Pickle height
Recovery height/Safety/g limits/Weapon Debris Envelope
Wind
Stby Sight Settings
Sun
Hazards
Defences

13. **MISSED IP, MISSED TARGET:**

Procedures, RT

14. **WITHDRAWAL:**

Run-out heading, speed
Formation reform - TRP
Target damage assessment - re-attack?
Battle Damage

Hung Weapon Tactics
Tactics if intercepted
Route - MEAs - fuel checks - defended areas
RV points
Recovery through friendly defences
In-flight reporting frequency and Agency

15. **AIR-TO-AIR REFUELLING:**

RV points
Callsigns, frequencies
Height, speed

16. **RECOVERY:**

IFF
Formation order
Type of approach

17. **EMERGENCIES:**

Air/Ground losers, RT, Leader U/S, Wx, Birds
Battle, Fuel, Airframe/Engine, Diversions/Safe route home
IFF Failure/NBC

18. **SAR & E&E CONSIDERATIONS:**

19. **TIME CHECK:**

20. **BRIEF:**

Weapon Emergencies
Disorientation

21. **EMPTY POCKETS:**

Dog Tags
F189
NBC Kit
Weapon
First Aid Kit
Rank Badges
E&E remainder

22. **QUESTIONS:**

Notes:

1. For peacetime exercises the following should be added to the brief:

    a. Notams

    b. Peacetime Rules

    c. Range Procedures

d. Weather abort plan

2. Where possible QWIs and EWIs should brief relevant parts of the mission.

3. For monitoring purposes sqn ops should be informed when the briefing is complete.

4. If after briefing the crews are told to 'Stand On' there must be updates of Int/IFF/FLOT/FSCL/Time Checks.

CHAPTER 8 - AIR-TO-AIR REFUELLING

GENERAL PROCEDURES

1.(R) AAR is to be conducted in accordance with HQSTC Air-to-Air Refuelling National Instructions (AARNI) which are included in ATP 56. The document includes details of Tactical AAR and all other types of AAR tanker used by NATO. ATP 56 should always be consulted for details of tasking, refuelling equipment, RV procedures, formation, safety, communications procedures and accompanied let-down.

2.(R) Since there is unlikely to be any radar assistance to find tankers in their orbits, Tornado crews should be fully conversant with RV SOPs. Additionally, it is possible that if home base runway was damaged, aircraft would have to take-off with little fuel, thus requiring low-level, tactical AAR.

3.(R) **Tactical AAR.** Tactical AAR shortly after take-off was proved feasible by Trial KIX where procedures were established for Jaguar aircraft to take-off with 20-25 min worth of fuel, carry out low level AAR (LLAAR) and then fly on to operational airfields. However, a strike mission could generate a need for LLAAR from small tankers, ie Buccaneer, and so Operation SAWN was flown (MAR/5550/Ops dated Feb 86). The procedures which were proved for Buccaneer/Tornado AAR are given at Annex A. The demise of the Buccaneer Force has left a capability gap in TAAR which may, in the future, be filled by Tornado buddy-buddy procedures.

4.(C) **RV Procedures.** The RV procedure which lends itself most easily to Tornado operations from the UK is the ATP56 RV6 modified for a timed RV on track. The success of the RV depends on the tanker and receivers arriving at the RV on track and heading at the correct time. It is important for all receivers to depart the AAR area with sufficient fuel for the mission, which will require careful planning. Detailed procedures for AAR are well documented in Tornado AAR SOPs, but it should be remembered that to complete an RV and refuel will take 2 aircraft approximately 15-20min and with the reduced performance/height available to a heavy aircraft, may take longer (for recommended AAR altitudes at heavy AUW see Aircrew Manual) If only one tanker is available, completing missions as pairs may need to be considered if excessive loitering of some formation members is not possible.

5.(C) **GMR Procedure.** The slant-to-plan range conversion carried out by the GMR causes a problem for GMR aided RVs carried out at height. The conversion effectively suppresses radar returns out to a distance in front of the aircraft equivalent to the altitude. This problem can be overcome by overwriting the system height as zero. Of course, system height should be re-datumed correctly as soon as possible to retain navigation system accuracy. The introduction of EV3 standard radar should aid GMR RV procedures.

OPERATIONAL EMERGENCY AAR

6.(R) All AAR qualified Tornado pilots are familiar with their own National Procedures and regularly practise against RAF VC10K and Tristar aircraft. However, it may be necessary to utilize tanker aircraft from other nations during OOA operations as practised during Operation GRANBY.

7.(R) The following section gives guidance for crews who may be required to use the KC135 or KC10 tanker aircraft.

USAF GENERAL PROCEDURES (CONUS)

8.(R) **Refuelling Order.** When joining the tanker it is normal for the leader of the receiver formation to move straight to the precontact position, while 2, 3 and 4 take up the 'observation position' on the wing of the tanker. Number 2 would normally take one wing whilst 3 and 4 maintain formation, with number 3 taking up the observation position on the opposite wing as shown in Figure 5-8-1. Refuelling is normally in the order 1, 3, 2, 4 which avoids crossovers and reduces the risk of collision. As each member of the receiver flight moves in sequence into the precontact position, the remaining aircraft on the tanker's wing moves into the observation position. On completion of refuelling, the receiver at the precontact position takes up the normal formation position on the other aircraft in his element (ie, the outside position on the wing he had just left).

9.(U) The procedures outlined here are for guidance only and may change as SOPs etc are amended. ATP 56 (or In-Theatre procedures) should be used as the reference for up-to-date SOPs.

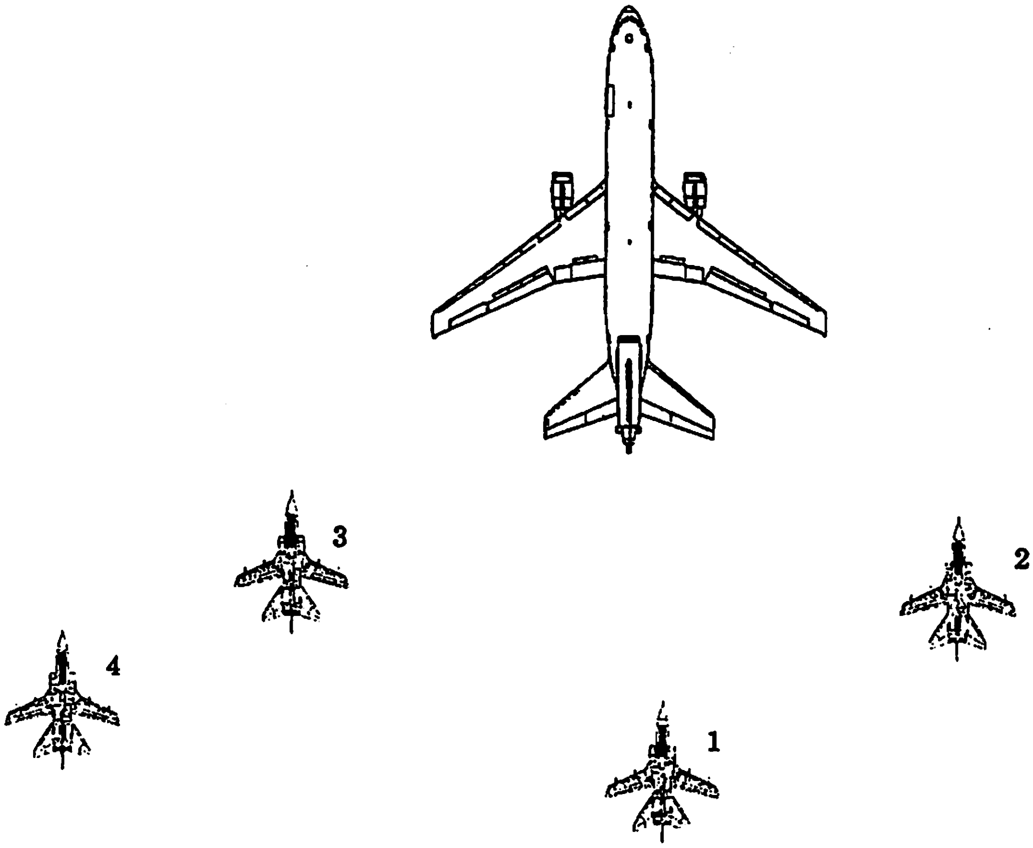


Figure 5-8-1 (R) - AAR - USAF "Observation" Positions

10.(R) **Radio Procedures.** The radio procedures for use with USAF refuellers are given in Table 5-8-1.

Position	Receiver RT Call	Tanker RT Call
Observation	"c/s Clear to pre-contact"	"c/s Clear to pre-contact
Pre-contact	"c/s Pre-contact stabilised and ready"	"c/s Clear to contact"
Contact	"c/s Contact - Fuel Flow"	"c/s Fuel Flow"
Contact (on completion of off load)	"c/s Ready for Disconnect"	"c/s Disconnect now"
Pre-contact	"c/s Clear"	"c/s XXX kg, clear to the observation position"

Table 5-8-1(R) - USAF AAR Radio Procedures

11.(R) **Visual Signals.** The visual signals for use with USAF refuellers are given in Table 5-8-2.

Signal	Meaning/Indication
1. Boom in trail	Ready for contact
(a) Extended 10 feet (1/2 length)	
(b) Fully Extended	1. Tanker Manual Operation without Tanker Disconnect Capability 2. Acknowledge Receivers MBL Signal
(c) Fully Retracted	Offload complete
2. Boom stowed	
(a) Fully Retracted	Tanker AAR System Inop
(b) Extended 5 feet (1/4 length)	System Malfunction. Tanker and Receiver Check AAR system
3. FLASHING PILOT DIRECTOR LIGHTS/TANKER LOWER ROTATING BEACON ON	EMERGENCY BREAKAWAY
4. PILOT Director lights go out during contact	Tanker request for disconnect. Go to pre-contact position

5. STEADY LIGHT FROM RECEIVER OR ROCK WINGS	EMERGENCY FUEL SHORTAGE EXISTS
6. FLASHING LIGHT FROM COCKPIT AREA	INITIATE 'TOBOGGAN' MANOEUVRE

Table 5-8-2 (R) - USAF AAR Visual Signals

KC135/KC135R TANKER

12.(U) The KC135 Boom Drogue Adaptor (BDA) consists of a 9 feet hose attached to the end of the telescoping part of the boom by a swivelling coupling. The hose terminates in a hard, non collapsible drogue. The telescoping part of the boom is kept fully extended whilst the BDA is in use. The KC135 boom envelope is shown in Figure 5-8-2. Refuelling heights from sea level to in excess of 30,000 ft are available and the recommended speed range is 260-300 kn (with 280 kn stated as the optimum). The maximum transferable fuel load varies from 84,870 kg to 92,060 kg. However, the maximum off-load during a 4 hour sortie is approximately 57,560 kg to 61,280 kg. Transfer rate through the BDA is 1270 kg/minute at 50 ±5 psi. The primary fuel type is F40 with alternate fuels of F34, F35 and F44.

13.(U) All aircraft undersurfaces are illuminated by floodlights which are adjustable for brilliance. Also provided are Pilot Director Lights which give positioning information in contact and during disconnect when using the boom and receptacle technique. Aircraft lighting is shown in Figure 5-8-3.

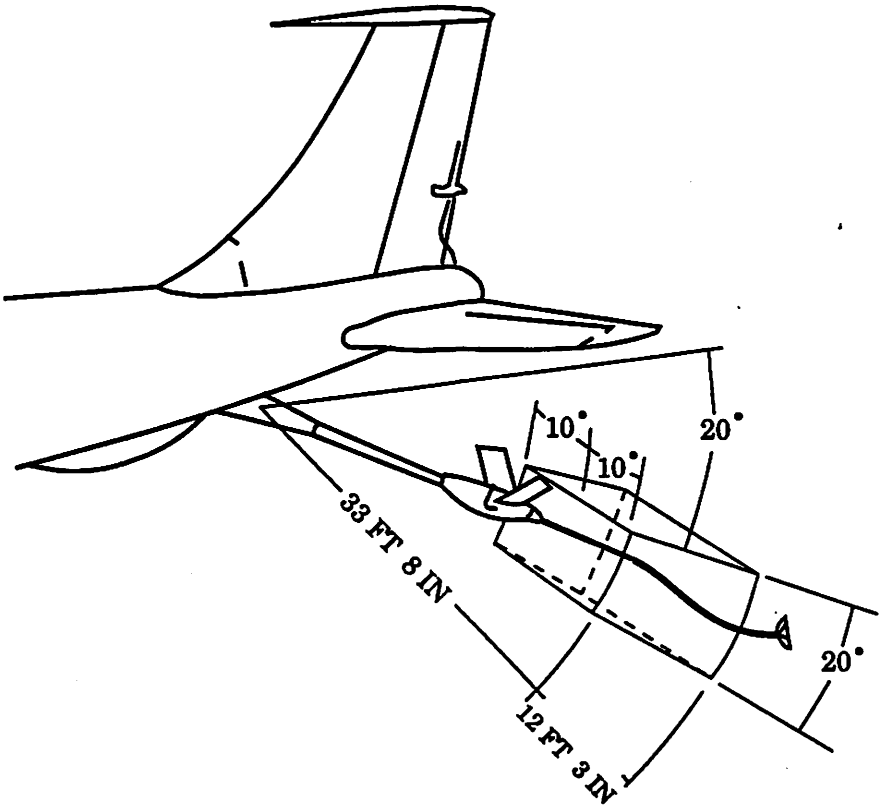
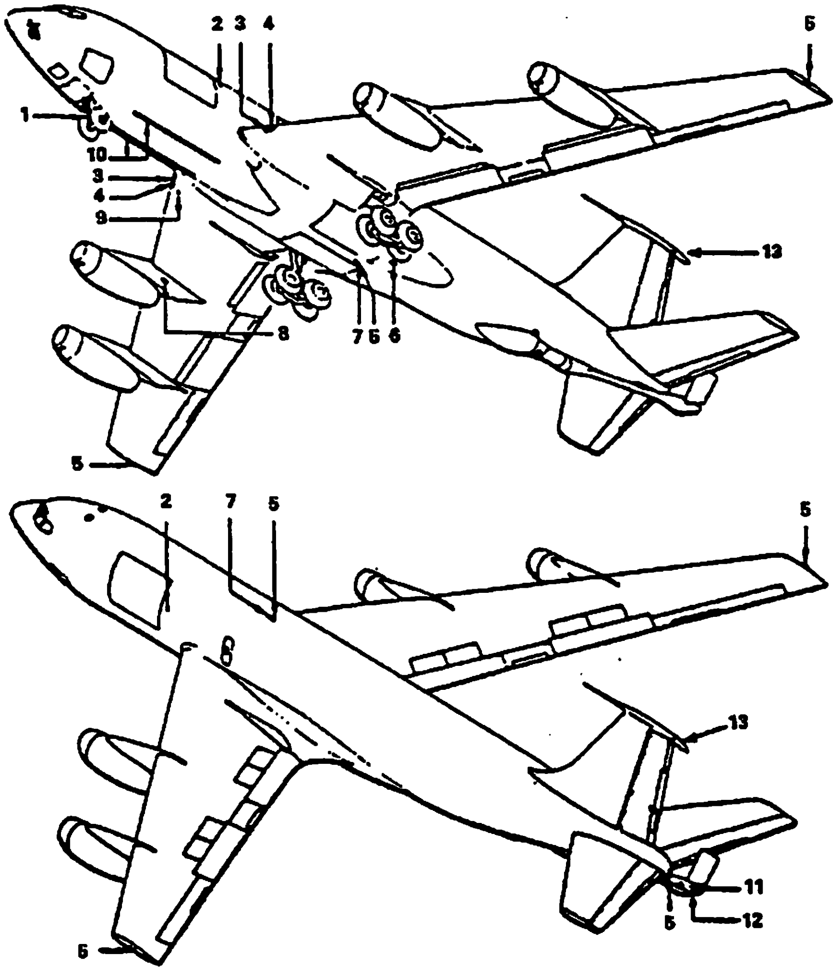


Figure 5-8-2 (R) - KC 135 Boom Envelope Limits



1. NOSE LANDING AND TAXI LIGHT
2. NACELLE ILLUMINATION LIGHT (TYPICAL) (2 PLACES)
3. TAXI LIGHT (2 PLACES)
4. LANDING LIGHT (FIXED) (2 PLACES)
5. NAVIGATION LIGHT (7 PLACES)
6. UNDERWING ILLUMINATION LIGHT (TYPICAL)
7. ROTATING BEACON LIGHT (2 PLACES)
8. UNDERBODY ILLUMINATION LIGHT (TYPICAL)
9. TERRAIN LIGHT (RETRACTABLE)
10. RECEIVER PILOT DIRECTOR LIGHTS
11. BOOM MARKER LIGHTS (FLUORESCENT)
12. BOOM NOZZLE LIGHT
13. AAR FLOOD LIGHTS

Figure 5-8-3 (R) - KC 135 Exterior Lighting

14.(R) **Observation Position.** References to be used for the observation position on a KC135/R are as follows:

a. Line up trailing edges of KC135/R wingtips (which are approximately in line with the leading edge of the base of the fin).

b. Maximum vertical position so that the far wingtip can just be seen across the top of the rear fuselage.

c. The 'outside' man should fly formation on the 'inside' man using the standard 'Tornado' references.

d. **Caution.** Beware wingtip vortices.

15.(R) **Line Up Procedure.** The basket position of the BDA is much lower with respect to the tanker fuselage than with UK tankers. The tanker Pilot Director Lights (depicted in Figure 5-8-3) should provide a 'familiar' vertical reference.

16.(R) **Approach to Contact.** Maintaining good directional control during AAR with the KC135/R is more difficult than with UK tankers. The reaction between the hose and probe can create a yawing movement. During the approach to contact an overtake of 2 kn maximum should be used. This reduces the risk of striking the boom in the case of a missed contact.

17.(R) **In Contact.** When 'contact' is established, the boom tip should be used as the primary reference point for maintaining position, with frequent scanning of the tanker forward fuselage. The tolerance in the refuelling position is a 3ft radius sphere around the ideal point. The task of maintaining position is more demanding than with UK tankers. Following a successful contact, the hose rotates as the bend is formed. It has never rotated through more than 360° and has never contacted the aircraft.

18.(R) **Disconnects.** Prior to disconnect, the probe tip should be directly behind the boom tip (ie, straighten the hose!). Emergency disconnects use a similar technique. Any aggressive lateral input is likely to cause the basket to strike the windscreen or nose during an emergency disconnect.

CAUTION: IT IS EASY TO BEND THE PROBE WHEN CONDUCTING AAR FROM A KC135 DUE TO THE RIGIDITY OF THE HOSE. GREAT CARE SHOULD BE TAKEN AND WHERE POSSIBLE ANOTHER TANKER TYPE SHOULD BE USED.

KC10 TANKER

19.(R) The KC10 is similar in size to the Tristar. According to the TPs, many of the aspects of AAR associated with Tristar are similar in the case of the KC10, with one noteable exception. There is much more friction associated with the basket on the KC10, therefore, the 'contact' has to be very accurate (central) as the probe tends not to 'slide' into the basket as it does on UK tankers. Other than that, there is little information available on precontact set-ups and line-up procedures. The CTTO is assured that the KC10 should present no problems and that it is the preferred option over the KC135.

20.(U) **AAR Equipment.** The KC10 AAR equipment comprises one centreline flyable boom and one fuselage hose drum unit (HDU). The HDU is mounted on the lower rear fuselage; the hose exits from a tunnel which is offset 4 feet to the right of the aircraft centreline. The hose is 80 feet long, of which 70 feet trails from the tunnel. The hose is marked by 2 foot wide white bands as shown in Figure 5-8-4. The hose AAR height band is SL to 35,000 ft with a speed range of 200 to 325 kn. The total transferable fuel during a 4 hour flight is 113,330 kg; the transfer rate is 1,110 kg/min and AAR pressure is 50 ±5 psi. The fuel types available are the same as the KC135.

21.(R) **Observation Position.** References to be used for the observation position on a KC10 are as follows:

a. Line up the near wingtip trailing edge with the front of the fin engine intake.

b. Maintain a vertical position so that the far wingtip can just be seen between the fuselage top surface and below the fin engine housing at the leading edge of the fin.

c. 'Outside' Tornado take references from 'inside' Tornado using standard references.

d. **Caution.** Beware tip vortices. Overall size of aircraft will tend to cause pilot to sit wide.

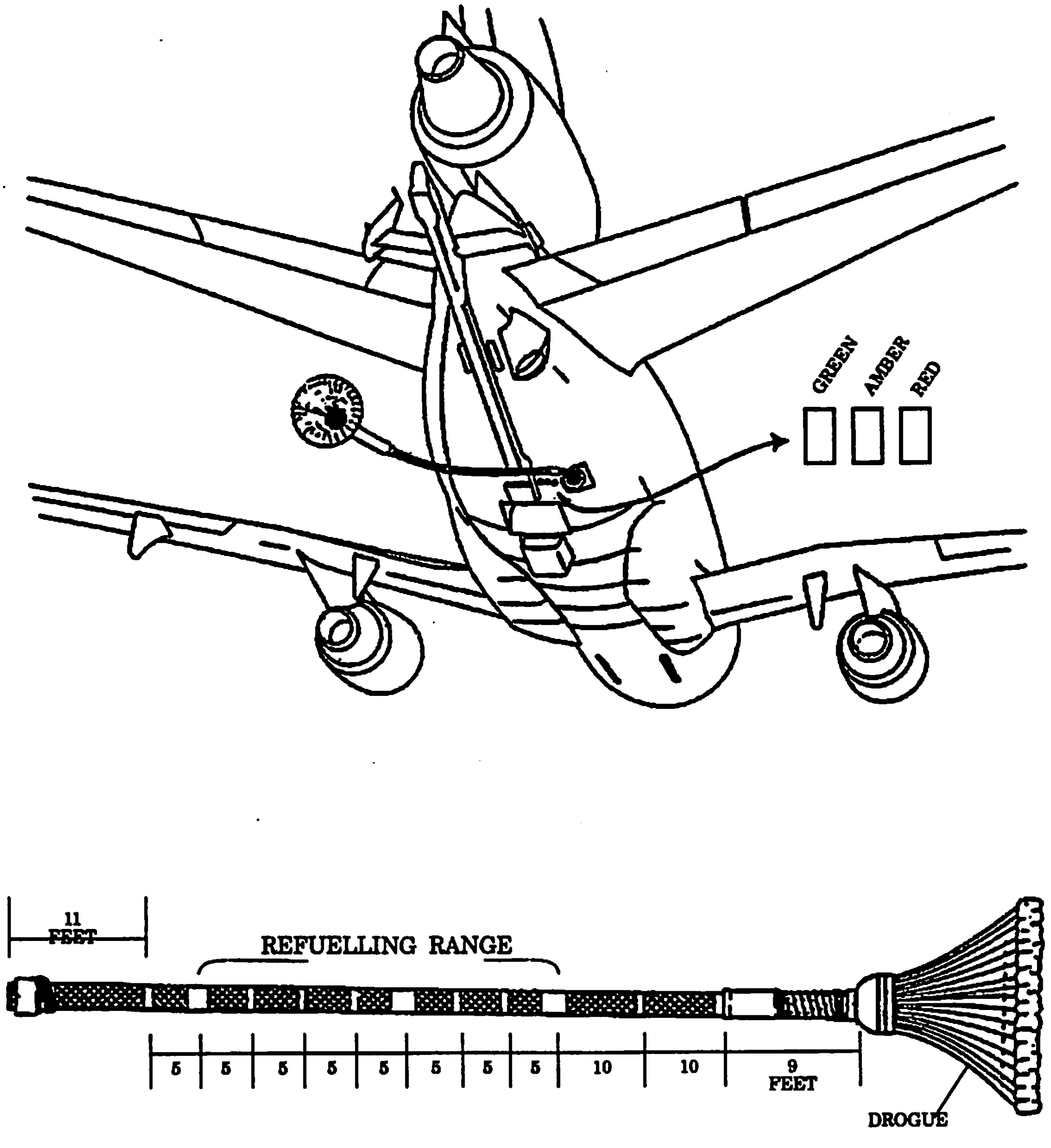


Figure 5-8-4 (R) - KC10 Drogue Signal Lights and Hose Markings

22.(U) **Lighting.** Aircraft lighting is shown in Figures 5-8-5 and 5-8-6. Pilot Director Lights have the same function as on the KC 135 but are positioned further aft (see diagram). A set of signal lights are positioned to the left of the hose tunnel on the rear fuselage and are coloured red, green and amber. The lights signals and their meanings are detailed in para 24.

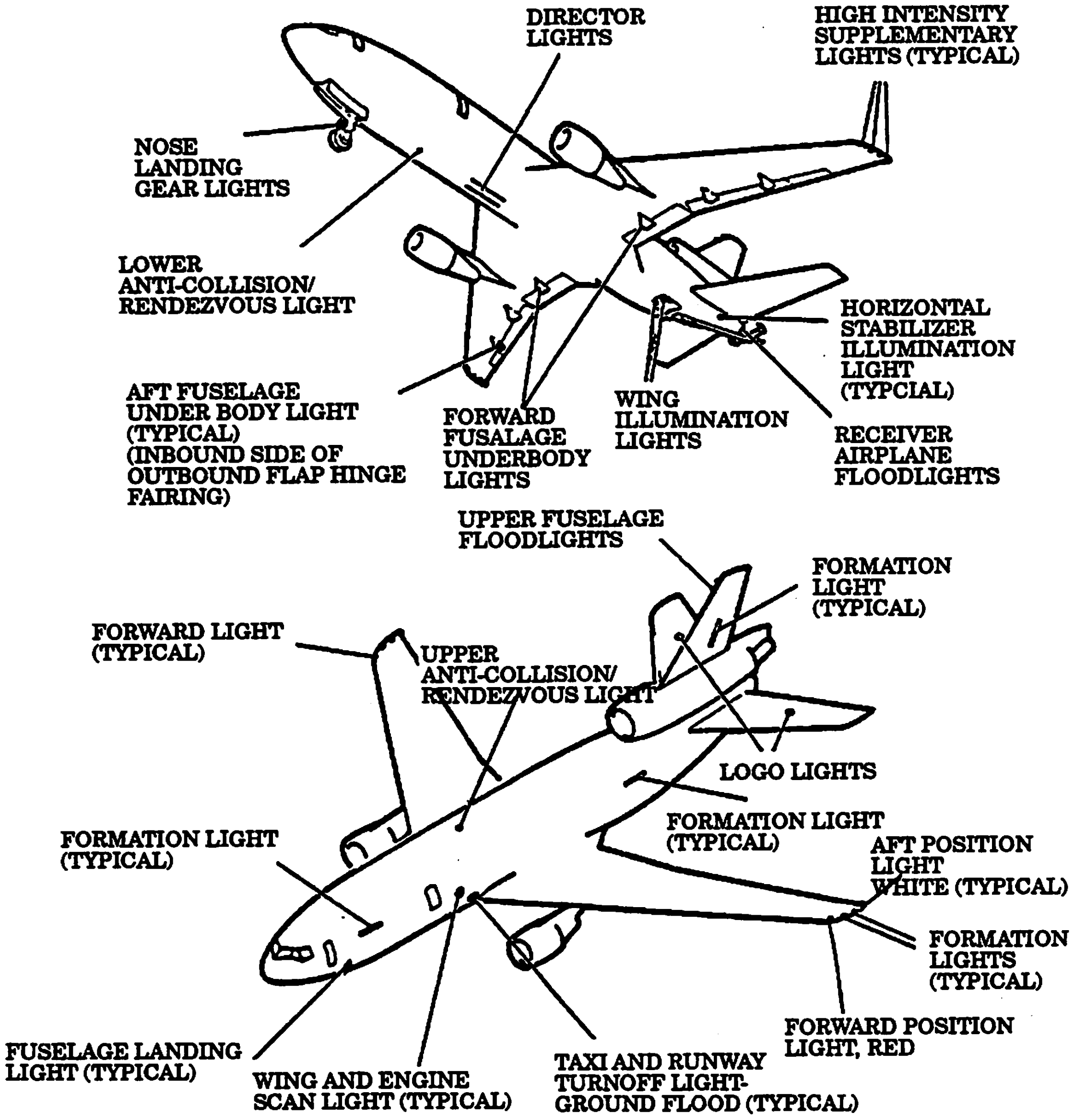

DIRECTOR LIGHTS
HIGH INTENSITY SUPPLEMENTARY LIGHTS (TYPICAL)
NOSE LANDING GEAR LIGHTS
LOWER ANTI-COLLISION/ RENDEZVOUS LIGHT
HORIZONTAL STABILIZER ILLUMINATION LIGHT (TYPCIAL)
AFT FUSELAGE UNDER BODY LIGHT (TYPICAL) (INBOUND SIDE OF OUTBOUND FLAP HINGE FAIRING)
FORWARD FUSALAGE UNDERBODY LIGHTS
WING ILLUMINATION LIGHTS
RECEIVER AIRPLANE FLOODLIGHTS
UPPER FUSELAGE FLOODLIGHTS
FORMATION LIGHT (TYPICAL)
FORWARD LIGHT (TYPICAL)
UPPER ANTI-COLLISION/ RENDEZVOUS LIGHT
LOGO LIGHTS
FORMATION LIGHT (TYPICAL)
FORMATION LIGHT (TYPICAL)
AFT POSITION LIGHT WHITE (TYPICAL)
FORMATION LIGHTS (TYPICAL)
FORWARD POSITION LIGHT, RED
FUSELAGE LANDING LIGHT (TYPICAL)
WING AND ENGINE SCAN LIGHT (TYPICAL)
TAXI AND RUNWAY TURNOFF LIGHT-GROUND FLOOD (TYPICAL)

Figure 5-8-5 (R) - KC10 Exterior Lighting (View 1)

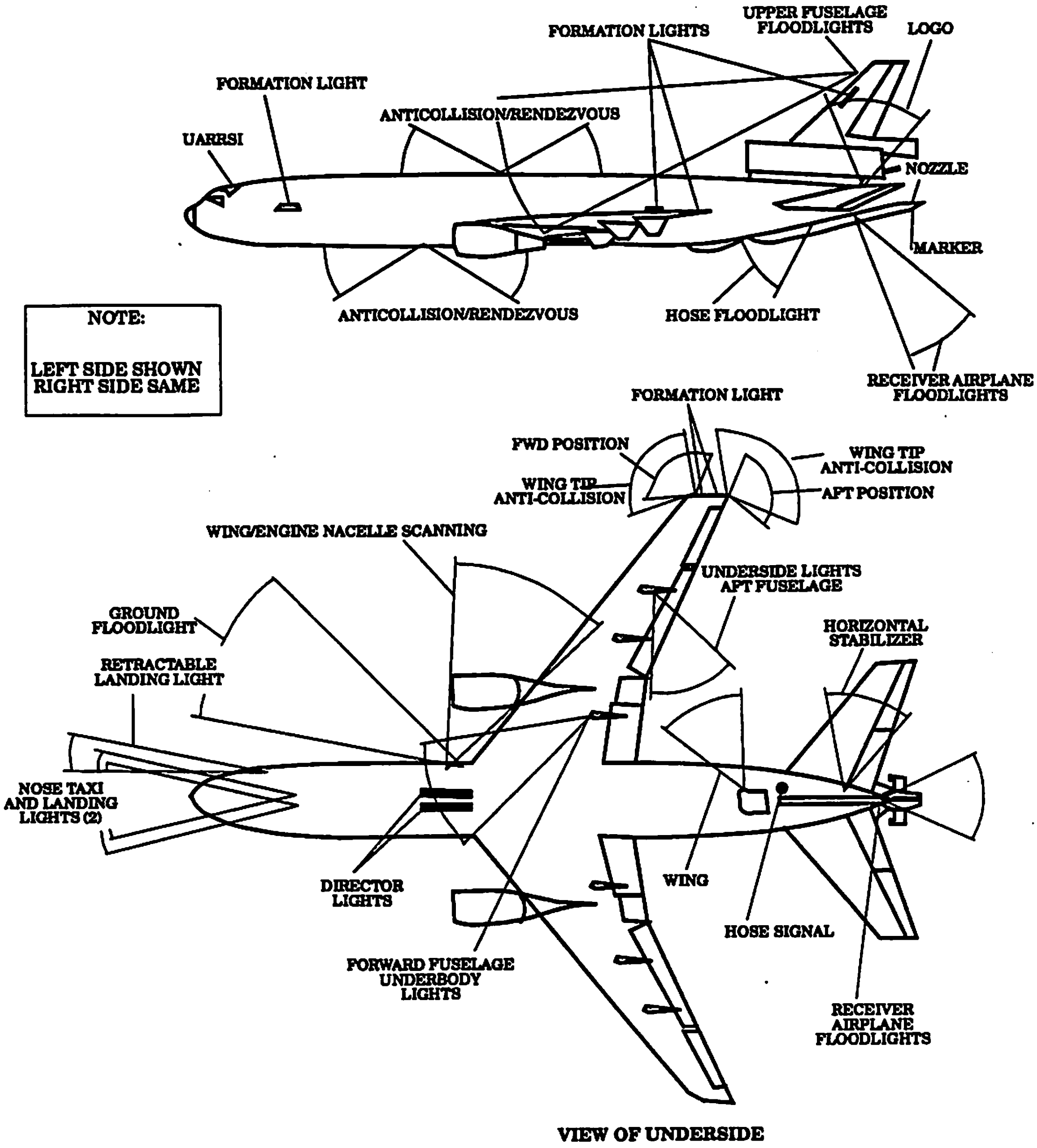


Figure 5-8-6 (R) - KC10 Exterior Lighting (View 2)

23.(R) **Contact Technique.** The ideal overtake speed is 3 kn; overtake in excess of 5 kn may cause hose oscillation. The hose must be pushed in at least 5 feet, indicated by the first of the white bands, to start fuel flowing. The ideal position is reached when a further 20 feet of hose is pushed in, indicated by the second white band. A further 15 feet of hose can be pushed in (within refuelling envelope), but the inner limit is marked with a third white band. Fuel flow ceases if the inner limit is exceeded and the amber light flashes. The hose should be maintained in line with the tunnel. Above 275 kn good contacts are more likely if the probe contacts the centre of the drogue; off-centre contact may be 'soft' and may result in some fuel spray.

AL2 (MS)

24.(U) **KC10 Hose Drum Unit Light Signals.** The KC10 HDU light signals are given in Table 5-8-3.

HDU Signal	Action
Steady Red	Do not make contact If in contact - breakaway
Steady Amber	Tanker ready for contact
Steady Green	Fuel flows
Green Extinguishes (Whilst receiver in normal refuelling position)	Transfer complete
Flashing Amber	Hose is pushed too far in (Inner Limit)
All 3 lights out	Disconnect
Flashing Red	BREAKAWAY

Table 5-8-3 (R) - KC10 HDU Light Signals

ANNEX A TO
SECTION 5, CHAPTER 8 OF
TORNADO GR1 TACTICS MANUAL

BUCCANEER - TORNADO AAR PROCEDURES

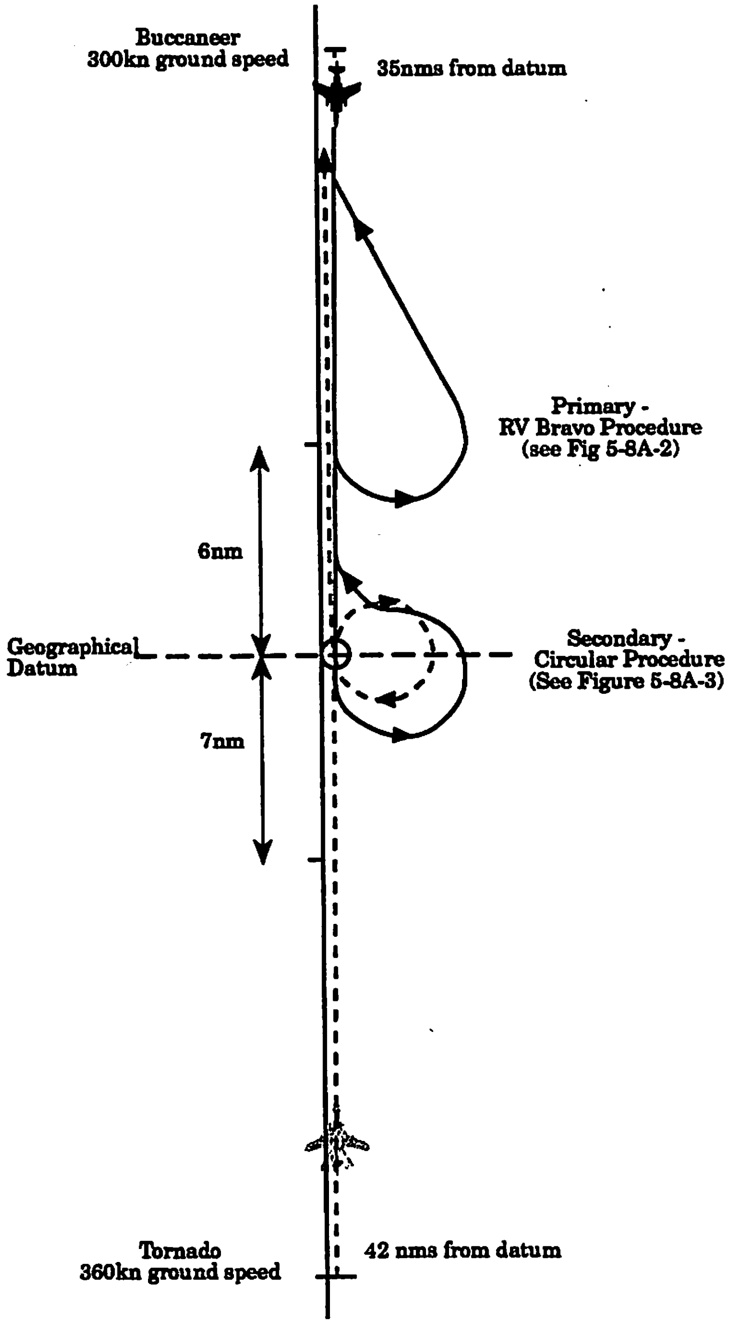
1.(R) The following procedures were proved during Buccaneer/ Tornado AAR sorties during 1986 and provide a basis for AAR operations which require the utilisation of small tankers.

2.(R) The planned sequence of events is given in Table 5-8A-1 below. A graphical illustration of the full RV procedure is shown at Figure 5-8A-1, and more detailed illustrations of the Primary and Secondary procedures are at Figures 5-8A-2 and 5-8A-3 respectively.

PLANNED SEQUENCE OF EVENTS

Elapsed Time	Action by Buccaneer		Split Range
	Any speed required to make the timing point Buccaneer crew has control of RV		
ZERO	Buccaneer timing point Start stopwatch 300kn groundspeed	Make initial RT contact TACAN On	77nm
1.00 min		DF (assess)	-
2.00 min		DF (action)	55nm
3.00 min		DF (action)	44nm
4.00 min		DF (action)	33nm
5.00min	Possible Buccaneer radar contact		22nm
5.49min		BRAVO Procedure (Figure 5-8A-2)	13nm
(7.00min)	(35nm to Buccaneer Timing Point) Geographical Datum CIRCULAR Procedure (Figure 5-8A-3) (42nm to Tornado Timing Point)		(Zero)
5.49min		BRAVO Procedure (Figure 5-8A-2)	13nm
5.00min	Possible RHWR Illumination		22nm
4.00min	DF	Possible radar contact	33nm
3.00min		DF (action)	44nm
2.00min		DF (action)	55nm
1.00min		DF (assess)	66nm
ZERO	Tornado timing point 360 kn groundspeed	TACAN On	77nm
	Any speed required to make timing point Planned egress track		
Elapsed Time	**Action by Tornado**		**Split Range**

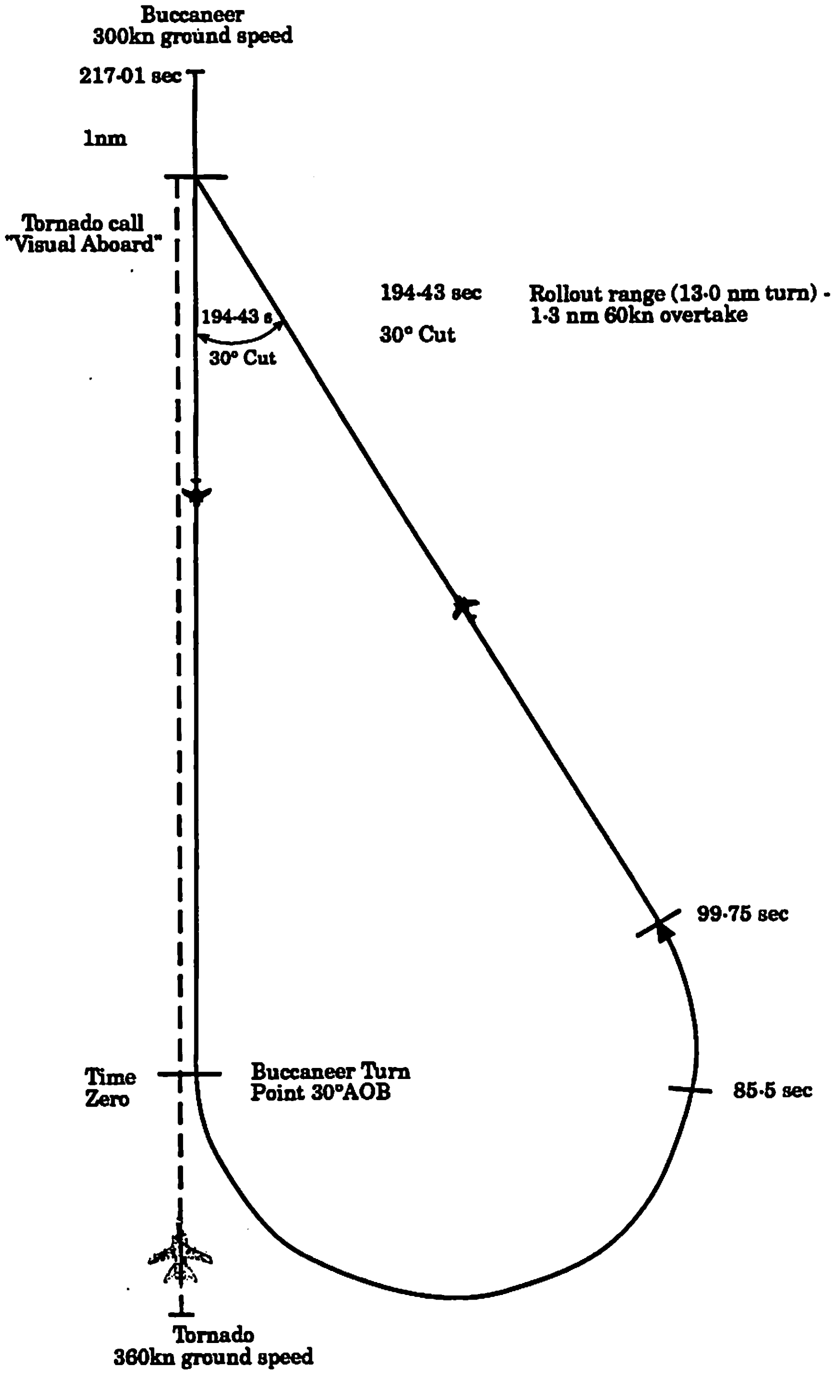
Table 5-8A-1 (R) - Buccaneer/Tornado AAR - Planned Sequence of Events



Notes:

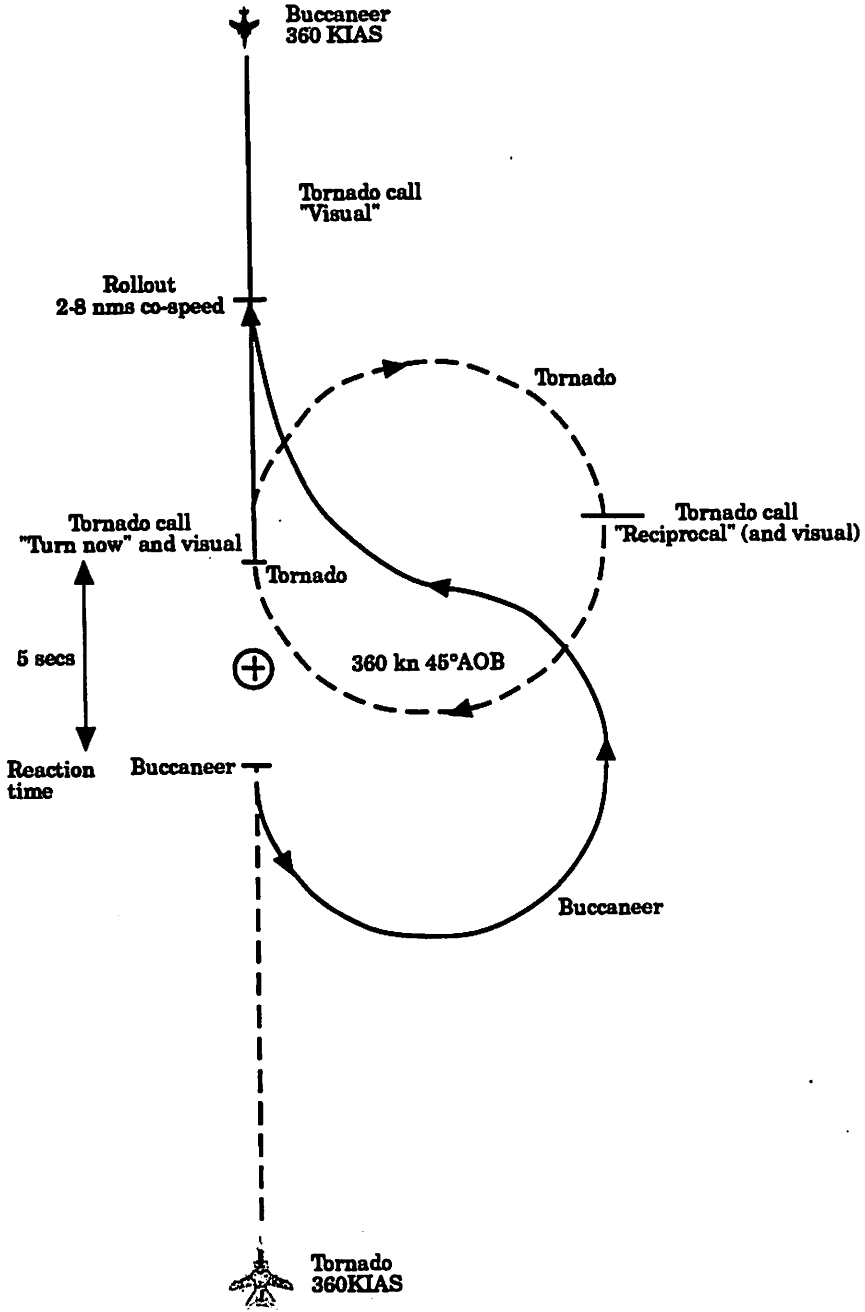
1. Initial set-up is to make the datum time, head-on and zero displacement.
2. If ranging information is available, the BRAVO RV procedure is to be used.
3. If no ranging information is available, then the Circular RV procedure is to be used, the Buccaneer is to increase its speed to 360 KIAS.
4. If both RVs fail, both aircraft are to fly to the Geographical Datum at the briefed altitudes and orbit at 30° AOB until visual acquisition is obtained.

Figure 5-8A-1 (R) - Buccaneer/Tornado Full RV Procedure



Tornado range from Buccaneer Turn Point - 12·7 nm
Flight Profile Turn at - 13·0 nm

Figure 5-8A-2 (R) - Primary RV Procedure - RV BRAVO



Notes:

1. After fai;lure to RV using Primary procedure, the Buccaneer accelerates to 360 KIAS. The Tornado changes from 360 kn groundspeed to 360 KIAS.
2. Separation of 1,000ft is maintained.
3. When the aircraft pass each other, the Tornado executes a righthand turn through 360° using 45° AOB. The Buccaneer executes a lefthand turn through 270° using 45° AOB then reverses onto the reciprocal (approach heading) through 90°.
4. On rollout the Buccaneer slows to 300kn.

Figure 5-8A-3 (R) - Secondary RV Procedure - Circular RV

Section 6

Sortie Tactics

Chapter 1 In Flight Procedures
2 Self Defence
3 Target Area Tactics

SECTION 6 - TABLE OF CONTENTS

CHAPTER 1 - IN FLIGHT PROCEDURES

Page Number (within the Chapter)

INTRODUCTION 1

PROTECTIVE MEASURES 1

INITIALISATION OF MAIN COMPUTER NAVIGATION SUB-SYSTEM 1
  Horizontal Accuracy 1
  Vertical Accuracy 2
  Navigation System Accuracy in Reversionary Modes 2
    IMC Formations 2
    System Height Channel 2
    Terrain Following (TF) 2
    Recommendations 2
TAKE-OFF AND FORMATION JOIN 3

SELF DEFENCE AND WEAPONRY CHECKS 3

ROUTE AND TIME-LINE 3

FIXING 4

IFF 4

SUMMARY 4

CHAPTER 2 - SELF DEFENCE

INTRODUCTION 1

SURFACE-TO-AIR MISSILE (SAM) SYSTEMS 1
  Tactical Routeing 1
  SAM Engagements 1
  SAM Avoidance (Radar Guided) 2

VULNERABILITY TO AAA 2
  General 2
  Vulnerability 2
  Guns Weaves 2

AAA DEFENCES 3
  ZU-23 3
  ZPU-2 or ZPU-4 3
  Small Arms and 12.7 mm Light AAA 3
  ZSU-23-4 3
  S-60 Battery. 3
  2S6/SA-19 3
  Barrage or Sector Barrage with Aimed Fire 3
  Gun Systems 4

DEFENCE AGAINST GROUND THREATS 4

THE FIGHTER THREAT 4

MISSILE THREAT 4
- IR Missile Performance. 4
- IR Missile Counters 5
- SA Missile Threat 5
  - SA Missile/AI Radar Characteristics 5
  - PD Aircraft/Missile Threat 5
  - Pulse Threat 6
- Gun Threat 6
- Threat and Missile Avoidance 6
- Attack Confirmed 6
- Tornado Performance 6

DEFENSIVE WEAPONS - SIDEWINDER AAM 7
- Ground Check 7
- Missile Modes 7
  - Boresight Mode 7
  - Scan Mode 7
  - Slave Mode 7
- HUD Modes 7
- Sight Handling 8
  - BRST 8
  - SCAN 8
  - SLVE 8
- Missile Selection 8
- Auto Function 8
- Indication Problems 9
- Seeker Head Performance 9
- Acquisition Boundary 9
  - Target Engine Power 9
  - Engine Power Changes 9
  - Engine Exhaust Position and Shielding by Target Structure 9
  - Atmospheric Absorption 10
- Background Interference. 10
- Capability against IR Decoy Flares 10
- Single-Shot Kill Probability (SSPK) 10
- Sight Handling 10
  - Advantages of Launch in Acquisition 10
  - Advantages of Launch in IR Lock-on 10
- Harmonization 11
- AIM-9L Employment - Summary 11
- AIM-9L - Summary of Low Level Performance 11
- Pitch-up Firing Tactic. 11
- Suggested Techniques for the Operational Employment of the AIM-9L Sidewinder 13

DEFENSIVE WEAPONS 13
- Launch Ranges 14
  - Minimum Range 14
  - Maximum Range 14

DEFENSIVE WEAPONS - BOMBS 14
  1,000 lb Retard Bomb 14
  CBU Defence 18

SUMMARY - FIGHTER THREAT 18
  Tactics - Basic Concepts. 18
  Recommended Tactics 18
    Front Hemisphere 18
    Beam Position 19
    Rear Hemisphere 19

ANNEX A - SURFACE-TO-AIR GUN SYSTEMS

INTRODUCTION A1

GUN SYSTEMS A1
  Gun System Characteristics - Table 6-2A-1 .... A2
  Projectiles A3
  Projectile Characteristics - Table 6-2A-2 .... A3
  Types of AAA Fire Control. A4

AIMED FIRE A4
    Effective Fire Region. A4
    Radar Controlled Weapons A4
    General A4
  Aimed Fire - Automatic Weapons and Optically Controlled Guns - Figure 6-2A-1 .... A5
  Aimed Fire - Radar Controlled Weapons - Figure 6-2A-2 .... A6

SECTOR INTERCEPT FIRE A4

BARRAGE FIRE A7

COMBINATION FIRE A8

FIRE CONTROL SYSTEMS A8
  Characteristics of Type of AAA Fire Control - Table 6-2A-3 .... A7
    Open Sights A8
    On-Mount Optical Mechanical Computing Sights A8
    Electro-mechanical Fire Control Directors A8
      Radar Range Only. A8
      Radar Mode A8
      Optical for Constant Altitude Targets A8
      Optical for Target Resolution A8
  Sector Intercept Fire - Figure 6-2A-3 .... A9
  Barrage Fire - Figure 6-2A-4 .... A9

LAND-BASED GUN SYSTEMS A10
    The Future. A10
    Retrofits A10
    General A10
  Anti-Aircraft Gun Characteristics - Table 6-2A-4 .... A11

CHAPTER 3 - TARGET AREA TACTICS

INTRODUCTION 1

TARGET DEFENCES. 1
    Against SA-8 1
    Against SA-3 1
    Against ZSU-23-4 1

OCA TACTICS 1

AI TACTICS 2
    Fixed Targets 2
    Mobile Targets 2
    Bridging/Choke Point Tactics - Visual Conditions 3
FAC TACTICS 3

BAI TACTICS 3

    Recce-Attack Interface (RAI) and Attack-Attack Interface (AAI) 4
OFF-TARGET TACTICS 4

    Battle Damage 4
MEDIUM LEVEL TACTICS 4

RE-ATTACKS 5

ANNEX A: CLOSE AIR SUPPORT

CAS - THE CR PERSPECTIVE A1
    TOTs A1
    Rear Brief A1
    FAC Brief A1
    RT A2
    Abort Codes A2
    CP Holding Procedures A2
    Formation Tactics A2
    Egress. A2
    Re-attacks A2

CAS - THE US PERSPECTIVE A3

THREAT SCENARIO A3
    High Threat A3
    Low/Medium Threat A3

HIGH THREAT A3
    Communications A3
    Use of VHF A3
    Inter-Aircraft Communications A3
    Abort Code A3
    Attack Roles A3
    Suppressor A4
    Shooter A4
    Cover A4

Decoy A4
Recce A4
Choice of Formation. A4
Wedge A4
Line Abreast A4
Trail A4
Co-ordinated Pairs Attacks A4
Combined A5
Sectored A5
Simultaneous A5
Sequential A6
The Aircraft to Aircraft Briefing A6
    2-Ship Element A6
    4-Ship or Co-Ordinated 2-Ships A6
Summary - CAS Tactics. A6
JAAT A6

LOW/MEDIUM THREAT A7
Delivery Techniques A8
FAC to Aircraft Brief A8
Ingress and Egress A8
Target Area Formations. A8
Holding Within Elements. A8
Holding Elements Within a Formation A8
Weapons Delivery. A8
Methods of Delivery. A9

ANNEX B: TYPICAL MINI-LOFT PROFILE AND RECOMMENDED OPERATIONAL PROCEDURES

MiniLoft Profile - Fig 6-3B-1 .... B1
Recommended Operational Procedures B2/3
Time to Overflight Values - Max Dry Power - Fig 6-3B-2 .... B4
Time to Overflight Values - Max Reheat - Fig 6-3B-3 .... B5

ANNEX C: RECOMMENDED LOW LOFT TECHNIQUES

Use of Reheat C1
Loft in Non-Visual Conditions C1
Regaining TF C1
Parallel Track Loft Recoveries C1
Trial Reports. C1

INTENTIONALLY BLANK

CHAPTER 1 - IN FLIGHT PROCEDURES

INTRODUCTION

1.(U) This Section of the Manual assumes the reader has a thorough knowledge of the preceding sections and combines that information for practical application to operational sorties, both ingressing to and egressing from the target area. Chapter 1 of this section covers the recommended techniques and procedures to be used when flying operationally in a hostile environment, Chapter 2 recommends tactics to be utilised as defence against ground and air threats and Chapter 3 covers the recommended tactics for use in the target area. As in earlier sections, emphasis is placed on tactics to be used in non-visual rather than visual conditions.

2.(R) The foundations of a successful sortie are laid by thorough planning and briefing and by ensuring that each member of the crew or formation is aware of his duties and responsibilities throughout the flight. Many of these duties will have been practised in day-to-day training sorties and most will be established squadron or wing SOPs. The aim of this chapter is to present points sequentially for consideration within those SOPs.

PROTECTIVE MEASURES

3.(C) Under operational conditions, continuous assessment is made of the threat of nuclear, biological or chemical (NBC) weapons being used against friendly forces. On the basis of that assessment, decisions will be taken on the level of NBC protection required by aircrew. In times of highest threat crews will wear full NBC clothing plus AR5 for flight. The procedures for donning and doffing this equipment are time consuming and fatiguing, and its use generates an unwelcome amount of heat; the strapping-in procedures are similarly demanding. The combination of the two drills will increase the time required between briefing and take-off and could thus reduce the sortie rate. One method of saving time could be to leave crews with the aircraft in the HAS for a second sortie thus reducing the doffing and redonning requirement. However, thermal stress experienced by crews may preclude even this solution.

INITIALISATION OF MAIN COMPUTER NAVIGATION SUB-SYSTEM

4.(C) **Horizontal Accuracy**. The introduction of STANDFIX with SS7-104 removed the need to complete the two OTFs recommended by the aircrew manual and TTTE. STANDFIX functions after MAIN Mode has been selected by sampling the IN velocities at a rate of 0.1 Hz. If those velocities are perceived to be less than values equivalent to 4.4 kn of ground speed the aircraft is assumed to be stationary and a correction factor equal and opposite to the vectors is applied to the KALMAN FILTER (KF). In this way, whenever STANDFIX is operating, a model is being constructed by the KF of the IN drift rate. Thus the use of OTFs will, at best, bring no further improvement and at worst would degrade the KF velocities. To obtain the most accurate navigation sub-system before take-off the following procedure is recommended:

a. Carry out normal IN alignment to status 0.

b. Initialize the navigation sub-system in MAIN mode and enter the best PP available.

c. Allow the system to STANDFIX for at least 3-5 mins.

Several places around the airfield will need to be surveyed and marked to provide for all combinations of runway and taxiway. During the 1985 SAC

Bombing and Navigation Competition the crews aligned the IN for 20 minutes at a position accurately measured as described. After selection of MAIN mode the system was allowed to STANDFIX for 8-10 mins, the aircraft was taxied to the marshalling point and the system allowed to STANDFIX again for 10 mins. The results achieved were impressive: after $3^1/2$ hours flight and without accepting any fixes, average ROL errors were 0.3 nm with minimum and maximum figures of 0.06 and 0.6 nm. It should be noted that such excellent system performance is dependent on good doppler velocities which can be degraded by flight over sea and in or above cloud. BAe and AWC advise that the doppler should be put to TEST just before entering these conditions as the flashing 'R' is given only after several uncorrelated velocities have been fed to the MC. Operationally it is impractical to allow as much as 40 mins to initialize the navigation system; 20 mins should be sufficient and the use of STANDFIX and an accurate PP should enhance the horizontal accuracy of the MC calculations.

5.(R) **Vertical Accuracy.** It is important to initialize the height channel before take-off by taking a planned height fix. Because of barometric errors caused by aircraft velocity the AWC recommend that a height fix be taken shortly after take-off to provide a more accurate height channel at 420 kn. A TRADAR height fix can be inserted on the pan and used as a back-up if an airborne height fix is missed.

6.(C) **Navigation System Accuracy in Reversionary Modes.** Trial THACKERAY (Stage 3) investigated the accuracy of the MC reversionary modes in simulated IMC. The trial observations were as follows:

a. **IMC Formations.** The separation between aircraft in tactical formations flown at night or in IMC is based on the maintenance of the planned track and time. Safe separation, therefore, relies on the accuracy of the Tornado GR1 navigation sub-system. Consequently, aircraft operating in the DP/SR or AD/SR modes could inadvertently and unknowingly reduce the separation between aircraft, thereby increasing the risk of collision.

b. **Terrain Following (TF).** Some trials flying has been carried out to investigate the performance of the TF system when operating with reversionary navigation modes. Although the TF system may continue to perform satisfactorily there will be no internal cross-monitoring of the navigation sensor outputs. More importantly, the degradation of the Head-Up and E-Scope Displays will make their use unacceptable for monitoring TF flight.

c. **Recommendations.** When operating in Main mode, it may not be necessary to fix the navigation sub-system continually. However, crews should include as many pre-planned fixes as practicable in the route in order to achieve maximum accuracy from the navigation system when it is operating in a reversionary mode. With the navigation sub-system in the IN/MC mode, crews should be able to complete the mission successfully. However, following degradation to DP/SR or AD/SR, the poor and erratic performance of the navigation system considerably increases the risk of collision between aircraft in the same formation, moreover, the aircraft is unlikely to carry out a successsful attack. Therefore, the AWC recommends that crews abort attack missions at night or in IMC following the degradation of the navigation sub-system to DP/SR or AD/SR.

TAKE-OFF AND FORMATION JOIN

7.(C) At very high AUWs or on a short, battle-damaged runway, pairs take-offs are impractical and a stream take-off should be planned. In IMC it may be necessary to enter TF flight shortly after take-off with all aircraft flying individual routes. These routes will need to be carefully planned to allow aircraft quickly to enter their routes on time. To assist the expeditious entry into TF, the following extra pre-take-off checks should be completed:

RAD ALT Bug	Set (Wartime only)
TACAN	OFF/REC
HUD	RADIO
HSI Hdg Bug	Set

By using these pre-take-off and revised FCC TF checks the time taken to enter TF will be approximately 1 min 45 secs and the aircraft should travel just over 9 nm. TF flight may not be necessary immediately after take-off, but the TF system should be checked so that it can be engaged with confidence should the need arise.

SELF DEFENCE AND WEAPONRY CHECKS

8.(C) After completing the TF checks, the next priority is to organise the aircraft for self defence and weaponry. The following checks are recommended:

a. Missiles — Selected (to enable cooling)

b. Guns — Selected (both set to FAST)

c. WCP1

Weapons Package 1 — Selected: 1 retard bomb (if available) for self-defence

Weapons Package 2 — As required for attack

Selective Jettison — To clear wing tanks and bombs (for missile/fighter BREAK)

ROUTE AND TIME-LINE

9.(C) All OCA/AI sorties must be planned so that they can be flown in non-visual conditions. Although the planning for such a mission will take appreciably longer, it is the only way of guaranteeing an ability to fly the sortie regardless of any delays in required TOT or deterioration in the weather. All tasking agencies have now agreed a minimum planning time sufficient to complete an all-weather plan.

10.(C) The AWC highly recommends parallel track planning where both aircraft fly a fully pre-planned route. The distance between the tracks may vary to allow greater room for manoeuvre or for terrain masking. An adequate allowance must be made for aircraft operating with poor or degraded navigation sub-systems. In visual conditions, routes may be flown with more flexibility with the No 2 adjusting the spacing to cater for different threats or visibilities.

11.(C) The maintenance of an accurate time early late (TEL) is vital for a pair of aircraft in mixed weather if they are to achieve cross-cover for the visual portions of the route. More importantly, if more than one pair of aircraft are flying the same parallel tracks at close intervals eg. 30 secs, zero TEL at the planned ground speed is required to ensure adequate nose/tail separation. To avoid possible collisions in this case the maxim must be, *"You are in position if you are ON TRACK/ON TIME/ON SPEED but if any one of those three is wrong STAY CLEAR OF TRACK"*. There is no doubt that the Tornado is capable of very accurate TOTs and crews are well practised in maintaining that high level of proficiency in peacetime; nevertheless in an operational scenario TOTs will suffer. Thus, it is very important to allow crews a tolerance of approx ±10 secs in addition to the minimum separation required for TF trail. Co-incidentally this same allowance should be used when calculating the minimum separation over a DMPI when delivering retarded weapons. If there is no time allowance, crews will be forced to take an alternative TOT, necessitating more time in the threat area.

FIXING

12.(C) The planning of fixes has been covered in Section 5 of this Manual, but the importance of planning fixes such that only one aircraft in each pair is fixing simultaneously should not be underestimated. In this way no more than 50% of the formation will be "heads-in" at any one time. Again, wherever possible, fixes should be 3-dimensional so that by using laser it would be possible to correct height errors as well as horizontal errors. The accuracy of the height fix prior to an attack can have a marked effect on the success of the weapon delivery and thus it should be made at attack speed close to the target. It is advisable to have a back-up OTF planned as a precaution against missing the 3-dimensional fix or to cater for an unserviceable laser. It is also possible to update height using the BAA facility but, as for an OTF height update, this requires an accurate knowledge of the height of the ground AMSL which is being used for the update. IPs should be available as On Top Offsets if required.

IFF

13.(S) In conjunction with minimum risk corridors, the presence or absence of a correct IFF response is a major criterion used by air defence forces, both air and ground based, in their ROE. However, many factors could affect the performance of a responding IFF after interrogation eg. garbling (where two or more IFF sets are in close proximity and their responding signals interfere), jamming, or overloading of the system. The error most often seen during exercises, however, is an incorrect code setting for a particular time period. Until the Tornado force is equipped with IFF which can be programmed for an automatic change-over, it is vital for the crew's safety that the IFF is changed to the correct code punctually. The software modification to flash the TV TAB every 30 minutes is a step forward in alerting crews but future conflicts may require IFF code change-over at times other than on the hour and 'half past'.

SUMMARY

14.(R) Most aircrew have discovered that simply flying is a mentally demanding task; decisions and thought processes which would be simple on the ground become more complex and time consuming when airborne. This effect will be compounded by the high threat environment of an operational sortie and simple decisions will require even more mental agility. There are three counters to this drain on mental capacity: firstly, as realistically as possible, crews should practise wartime procedures in peacetime; secondly, plan as much as possible on the ground releasing limited brain capacity for airborne situations which cannot be adequately predicted; finally, evolve simple and effective SOPs which work. In summary, know what to do and practise it, plan as much as possible on the ground and Keep It Simple.

CHAPTER 2 - SELF DEFENCE

INTRODUCTION

1.(R) Operationally, after successfully completing a mission, the aim of Tornado GR1 crews is to return to base safely. To achieve this aim, crews may have to negotiate a route through sophisticated, densely deployed and extensive air defence systems. The aim of this chapter is to advise on self-defence tactics against ground and air threats.

SURFACE-TO-AIR MISSILE (SAM) SYSTEMS

2.(R) All SAM systems have well-defined lower limits to their coverage. A flight profile that remains below these limits is unlikely to be vulnerable to that particular SAM system although profiles that involve climbing/diving may be vulnerable if they remain within the engagement envelope for long enough.

3.(S) **Tactical Routeing.** One of the most decisive factors in reducing attrition rates is route planning designed to exploit the weaknesses of the SAM defences. As a specific example, it has been calculated that for two parallel routes through the FEBA, just 20 km apart, the attrition level on one route could be as low as one third the level on a route through an army HQ area. Thus, it is of vital importance to assess the disposition of ground forces from the very latest intelligence scenario before deciding the routeing through the FEBA. Even if the locations of SAM and other ADUs are not precisely known, plan to avoid HQ, troop or armour concentration, choke points or river crossing points as these are areas where the defences will be concentrated. Routeing via hilly or densely wooded terrain, where the ADU's task is much more difficult, would also increase the chances of successful penetration. Even with such precautions, the presence of some ADU sites may only be indicated when a radar engagement signal is received by the RHWR or by the visual sighting of a missile launch.

4.(R) **SAM Engagements.** A typical SAM system engagement comprises a sequence of principal events. In general, if the sequence can be broken then the result is an unsuccessful interception. Each phase of the sequence - detection, identification, acquisition, pre-launch calculations, launch and guidance - requires a finite time which can be exploited by the target aircraft. The time from the initial detection to the missile launch is termed the system reaction time, but not all of this period is always available for defensive action; indeed the missile launch is often the first indication of an attack, eg SAMs 7, 14, 9 or 13. All SAM systems are constrained by factors which can be degraded or defeated. The main factors are:

a. The propulsive and aerodynamic capability of the missile.

b. The guidance method used (line of sight, full lead or an intermediate method).

c. Tracker and missile seeker slew rates and sightline angle limits.

d. Maximum and minimum ranges of the missile.

e. Tracker performance (for command guidance).

f. Fuze-warhead performance.

Any SAM avoidance tactic or countermeasure that denies an essential requirement will generally result in an unsuccessful intercept.

5.(S) **SAM Avoidance (Radar Guided).** The RHWR may give the first indication that an attack from a radar guided SAM is imminent or underway. If the aircraft is at low level it should descend as low as possible to try to prevent a radar lock or break a lock already achieved. Simultaneously, the aircraft should turn to remain outside the lethal envelope of the particular SAM or, if this is not possible, turn to at least avoid overflight of the site. Subsequent actions will depend on whether the Sky Shadow pod is capable of providing a counter to the threat and are detailed below:

a. **Sky Shadow Counter to TTR Available.** The threat site should be maintained within the pod coverage for as long as possible as stated in Section 4 Chapter 3. This may result in an initial turn towards the threat to put it into the coverage of the pod followed by a sharp turn away to transfer the threat from the front to rear aerials of Sky Shadow. Apart from this one turn, the evasive manoeuvre need not be violent since the objective is only to increase the sight-line spin rate of the system. Furthermore, any violent manoeuvre with a full weapon load would certainly lead to a reduction in speed and probably an increase in height, thus resulting in the aircraft moving into a part of the SAM envelope where the system may be more capable. Chaff should also be dispensed from the BOZ pod during the evasive manoeuvre (Program 1 (IMC) or Program 2 (VMC) with TOR07).

b. **Sky Shadow Counter to TTR Not Available (excluding SA-8).** Using at least 2g, initiate a turn as soon as possible after the SAM system triggers the RHWR trimphone alarm. **Do not wait for MG/CG indications (eg Kojak alarm) before reacting as these may be detected very late, if at all!.** The turn, which should be away from the threat, should continue until the threat is on the beam (ie the aircraft is tangential to the TTR). Chaff should be dispensed during the manoeuvre (Program 1 (IMC) or Program 2 (VMC) with TOR07). If necessary, reinitiate the chaff program to ensure chaff is still being dispensed when the threat is on the beam. Continue to beam the threat and dispense chaff until the radar lock is broken then attempt to track progress, weaving and chaffing until well past the threat site. Be prepared to beam threat again if further trimphone alarms are heard. When attempting to counter a Roland threat during daylight, flares should be dispensed as the missile is tracked in its optical mode by an IR beacon mounted on the missile case; dispensing flares may degrade its optical mode or prevent, in the case of Roland 2, the operator from switching from radar to optical target tracking.

NB: At medium level, the aircraft should be flown in a weave and chaff released as 'g' is applied on the inbound turns to break the lock of a tracking radar. However, the system should be beamed and chaff dispensed as described above once the system becomes a threat, eg trimphone alarm heard.

c. **SA-8.** Some Sky Shadow PFMs now contain an ECM counter to the SA-8 TAR which can be enabled using the MODify button on the control panel. For these PFMs the procedures detailed in sub para b should be modified as follows:

1) When approaching a target or transitting a high workload area where SA-8 is known to be deployed, the whole formation should

enable the TAR counter at a pre-calculated unmask range.

2) Initiate a turn away from the SA-8, using at least 2g, as soon as possible after the trimphone alarm is heard. The whole formation should enable the TAR counter if not already enabled. Beam the threat and chaff as detailed in sub para b above; if possible, change height to make reaquisition more difficult.

3) Attempt to track progress as detailed in sub para b. Disable the TAR counter when clear of the site or the high workload area.

The procedures detailed in sub para b above should be followed in toto if the PFM to be used does not contain the ECM counter to the TAR.

6.(S) **SAM Evasion (Radar Missiles).** If you receive warning of a SAM launch and acquire the missile visually, the low and medium level tactics are as follows:

a. **Low Level.** At low level, a 2-stage attempt to out-manoeuvre the missile must be made. Firstly, stay as low as possible and execute a maximum 'g' turn towards the missile while deploying chaff and flares using the combined program (CP) selection. The objective is to turn inside the missile's minimum radius of turn while staying outside its lethal warhead radius should it detonate. If missile lock is not broken by this turn, then the second-stage evasive manoeuvre is a 3-dimensional break towards the missile while continuing to dispense chaff and flares. In all defensive manoeuvres, a heavy weapons load will reduce aircraft turning performance and thus increase the chance of a successful missile engagement; the decision to jettison weapons when under attack will depend on the circumstances. Finally, SAM battery tactics are to use missiles in salvo, so crews should avoid relaxing after a successful evasion - the first missile may just have been the first in a pattern.

b. **Medium Level.** To counter a missile at medium level, the aircraft should be manoeuvred to keep the threat on the beam and a barrel roll should be flown around the missile until a few seconds to expected impact when maximum 'g' should be pulled. Chaff should be released as the roll is entered and as the final pull is made. Simultaneous release of flares is recommended in daytime operations, but only at night if an IR threat is suspected.

7.(S) **SAM Evasion (IR Missiles).** The following procedure should be adopted to defeat IR guided SAM:

a. Deselect re-heat if appropriate. Select idle/idle power if possible.

b. Break towards the missile. If already close to the 12 o'clock, break to put the missile briefly on the beam. If possible change height to change the manoeuvring plane; a descending break would help to maintain speed. Use terrain if possible to cause the missile to lock on to the ground.

c. Dispense a pattern of 3 flares at 0.25 sec intervals immediately after starting the break. Also dispense chaff as there is a possibility that the missile may be RF-guided or fuzed. To dispense both, select CP which in TOR07 gives Flare Program 2 (3 flares at 0.25 seconds) and Chaff Program 4 (one second of chaff at 20 mm/s).

d. Having defeated the first missile look for the rest in the salvo!

NB. Trial ENSTATE found that for missiles approaching from the head-on sector, a manoeuvre to port rather than starboard increased the separation between aircraft and flare so enhancing the effectiveness of the flares.

8.(R) **Jettison of Stores.** Consideration should be given to the selective jettison of stores to reduce aircraft weight, aid manoeuvrability and allow a tighter break at both medium and low level. The Sky Shadow and BOZ pods together with the AIM-9 AAMs should be retained as their jettison would bring little benefit in turning performance and they may be needed for protection later

VULNERABILITY TO AAA

9.(S) During the Gulf conflict, AAA was a primary threat to low level operations. Typical AA systems were the ZSU-23-4 with its GUNDISH radar, the S60 system with FIRECAN or FLAPWHEEL and automatic or barrage AAA. Traditionally the ZSU-23-4 has been deployed with the army for point defence while the S60 has been used for defence of fixed targets such as airfields and bridges.

10.(R) **General.** AAA systems usually have 3 modes of fire control:

a. Full radar ranging and aiming.

b. Radar ranging with optical aiming.

c. Visual range estimation with optical aiming.

The first method suffers from long reaction times and the third is the least accurate but has very fast reaction times. The second method is a compromise and is thought to be the mode preferred by the Soviets.

11.(C) **Vulnerability.** Vulnerability to AAA can be reduced by making use of terrain screening to delay detection, by using manoeuvres to disrupt the prediction systems or by remaining out of effective gun range. Because of the use of optical systems for either pick-up or aiming, consideration must be given to the camouflage effect of terrain behind the aircraft as seen from the gun, and more importantly, the position of sun. Other things being equal, always try to attack out of sun. Once detected, although the aircraft may be vulnerable, remaining at low level limits the number of guns in a typical defensive layout that can engage the aircraft. Straight and level flight presents little problem to gun systems that rely on straight line fire prediction but most guns will be faced with a side rather than a plan view of the aircraft. Evasive manoeuvres will offer the guns a larger area to engage and are likely to result in an increase in height, which in turn exposes the aircraft to more systems and could include SAMs. However, evasive manoeuvres in the form of a guns weave will be necessary if the RHWR indicates that AAA is about to open fire, or if actually fired upon, and should provide an effective counter to fire prediction systems.

12.(R) **Guns Weaves.** All guns systems are less effective against receding targets than those approaching. Aircraft weaving at up to 2 'g' serves only to increase their vulnerability because flight path changes are small and the presented area of the aircraft is increased. Weaving at more than 2 'g' produces sufficient change of flight path to reduce the effectiveness of straight line prediction systems. Heading changes within weaves should be held for long enough to be effective - about 5 seconds. Rapid changes of bank and 'g' at shorter intervals will result in a flight path which is nearly straight, uncomfortable and an ineffective form of evasion.

AAA DEFENCES

13.(S) The main AAA threat is posed by 57 mm and 23 mm guns. A large number of systems are likely to be deployed and the probability of random engagement is significant. The threat posed by individual small arms to a high-speed, low-level target is also high, especially if concentrations of these weapons are overflown.

14.(S) **ZU-23**. The ZU-23 uses visual target acquisition and tracking and the gun is hand operated. Tactical range is 1.5 nm (9,000 ft) and rate of fire is 800-1,000 rounds per minute per gun. Calibre is 23 mm. Stay out of, or above its lethal range and use steep dive attacks with release altitude sufficient to recover by 10,000 ft.

15.(S) **ZPU-2 or ZPU-4**. The ZPU series of guns are based on 14.5 mm heavy machine guns. Tactical range is 1,400 m (4,650 ft). Stay out of, or above lethal range and use steep dive attacks with release latitude sufficient to recover by 5,000 ft.

16.(S) **Small Arms and 12.7 mm Light AAA**. Every soldier with a rifle is a potential threat in the battlefield area. Also the 12.7 mm machine guns fitted to MBT turrets can be a major threat if you are low enough. Avoid flight in the lethal envelope if it is not necessary. Fly above 2,500 ft.

17.(S) **ZSU-23-4**. The ZSU-23-4, which is a tracked, self-propelled, radar-laid, quadruple 23 mm gun, has an optimum range of 1,500 m, although it is effective out to 2,500 m. Its combined rate of fire is 3,600-4,000 rounds per minute, although the gun is normally fired in bursts of 1-2 seconds duration. The gun has 3 possible operating modes; these are radar tracking and ranging, optical tracking with radar ranging, and optical tracking and ranging. Although the radar tracking and ranging mode is the most accurate, this is unlikely to be used against a low-level target because the radar system has a 12 second reaction time. The operator would probably use the optical tracking with radar-ranging mode against a high-speed target.

18.(S) **S-60 Battery**. An S-60 battery comprises 6 guns and a FLAPWHEEL fire control unit. The guns are used for the defence of airfields and VPs and are usually deployed in a hexagon configuration. Each gun has a practical rate of fire of 70 rounds per minute and a slant range of 6,000 m. The radar mode poses little threat to a high-speed, low-level aircraft due to the minimum tracking elevation of 1.5° for the FLAPWHEEL radar and a radar reaction time of 8 seconds. However, the S-60 system could be effective optically against targets above 200 ft at close range.

19.(S) **2S6/SA-19**. 2S6 is a radar guided twin 30 mm AAA system mounted on a chassis which is similar to that of the SA-11 Telar. In addition 8 x SA-19 missiles are mounted on the turret. Rate of fire is probably 4,000 rounds per minute and fired in bursts of 15-20 rounds. Minimum effective altitude is 33 ft (missile and minimum range for missile is 1 km. Maximum range for missile is 7.8 km and for guns is 14,400 ft (4.4 km).

20.(S) **Barrage or Sector Barrage with Aimed Fire**. Against barrage or sector barrage fire with some aimed fire, the following tactics apply, regardless of the ECM configuration and target protection by SAM systems.

a. Stay above effective AAA fire if feasible.

b. Co-ordinated flak suppression attacks should precede the main strike by a brief period, usually less than a minute.

c. Co-ordinated strike attacks should be planned so that aircraft are over the target for the minimum time consistent with tactical requirements. Attacks from diverse sectors should reduce density of the sector barrage controlled fire.

21.(R) **Gun Systems.** A discussion of the AAA environment to be expected by aircrew during combat is at Annex A to this Section.

DEFENCE AGAINST GROUND THREATS

22.(S) Many of the options available for self defence have been covered in preceding paragraphs, namely use of Skyshadow to deny range, use of manoeuvre, chaff and IRDs, but one other distracting influence for defensive armament ahead of the aircraft would be the use of the Tornado guns fired in short bursts during a run-in to the target or when forced to overfly a defensive SAM or AAA site. The overriding consideration however, is that guns cannot be fired at the same time as releasing bombs, so at the final stages of an attack, the gun trigger must be released. Intensive gun firing trials have shown that repeated bursts of longer than 1½ seconds will almost certainly result in the need to replace the barrel after one sortie. Despite all the foregoing, experience during Operation CORPORATE and Trial PHASIA 3 has shown that the single most effective counter to enemy ground-to-air defences is to fly very low and make optimum use of terrain masking: flight at or below 100 ft markedly decreases vulnerability.

THE FIGHTER THREAT

23.(S) The problems of avoiding fighter aircraft at low level should not be underestimated. It is imperative that crews maintain a constant lookout, visually and electronically, to 'see first' and then to avoid the threat. Fighters are most likely to be used to provide in-depth defence behind the FEBA and as fighter escort for their ground attack operations. In particular, fighters could be expected in areas where ground defences have been suppressed, ie at the end of corridors made through the FEBA by defence suppression operations. However, the problems of co-ordination and deconfliction dictate that crews are unlikely to be faced with a simultaneous ground and air threat.

MISSILE THREAT

24.(R) Tornados may be engaged by enemy fighters using a variety of older and newer generation IR and semi-active missiles.

25.(R) **IR Missile Performance.** Fundamental to the success of an IR missile is that it must have good IR acquisition on the target before it is fired. It may be sensitive to the radiation from hot metal (the early uncooled seeker-head missiles) or to the jet plume. The missile seeker head must also discriminate between target radiation and that from clouds, the ground or, more importantly, the sun. IR radiation is attenuated by the atmosphere, in particular it is absorbed by moisture, so cloud and rain will exacerbate the acquisition problems. The minimum firing range is determined by the requirement to provide a safe-arming interval and for the missile to initiate and complete the initial intercept manoeuvre following the launch. Maximum firing range is dependent on the rocket motor and the amount of manoeuvring necessary to complete the intercept - generally in the rear hemisphere the missile acquisition range is greater than the aerodynamic range. The IR radiation of any target is decreased as the angle-off from the tail increases and generally a head-on attack (±20°) is only possible on a supersonic target or one using reheat. It should be noted, however, that in the front hemisphere the acquisition range is doubled when greater than ±30° off the nose, in elevation or azimuth, from that possible when almost dead head-on. The range at which a given target is acquired is also dependent on the target's power setting - reheat results in lock-on ranges two to three times that of maximum dry power. The time of flight of the IR missile is relatively short and allows little time for evasive tactics; a head-on missile closes at 3 seconds/mile and a stern intercept missile at 6 seconds/mile. The normal flight time of a stern firing is ONLY four to five seconds. Finally, even though the IR homing may be satisfactory, the success of the attack depends on the fuze-warhead combination, which in turn depends on the intercept geometry, the fuzing technique (IR, radar or laser) and the warhead mechanism.

26.(S) **IR Missile Counters.** Although a missile may have been launched at an angle-off which gave good acquisition and probability of success, an increase in angle-off by a target manoeuvring during the flight of the missile may result in a loss of acquisition and guidance prior to intercept. It is unlikely that the Tornado can out-manoeuvre a missile aerodynamically but a high sight-line spin rate may cause the missile seeker head to reach the gymbal limit and thereby cause loss of lock; this can be best achieved by putting the missile on the beam. The fuze system may be triggered prematurely if the missile approaches too close to the ground, eg. when guiding on a very low flying target, however, this is unlikely as typical IR missiles have a maximum fuzing radius of 45 ft. One limitation may be that current small Soviet-made missiles have radar fuzes which may be prematurely triggered by chaff. The power setting used by the target will also critically affect the guidance; if possible maximum reheat should be avoided. In particular, maximum reheat should not be used when countering a head-on fighter until the range is too close for a successful missile launch. Trials with AIM-9L have shown that occasionally IR lock can be broken by selecting idle power, particularly at the instant of evading. The use of IR decoys is also critical.

27.(S) **Rules for Defeating an IR Missile.** The countering of an IR missile is a complex subject open to much debate. However, when exposed to the shock of a combat engagement, any threat counter will be ruled by 2 simple principles; the missile TOF will be so short as to give the targetted crew little time to react and, as the crew will be under intense mental pressure, the counter they employ must be instinctive and simple. The best advice AWC can give to counter an IR missile threat is as follows:

a. Deselect re-heat if appropriate, idle/idle power selected if possible.

b. Break towards the missile. If already close to the 12 o'clock, break to put threat briefly on the beam, but only if the attacking fighter is at long range and is not allowed to arc the target as a result of the manoeuvre. If possible change height to change the manoeuvring plane; a descending break would help to maintain speed. Use terrain, if possible, to interrupt the missile's line-of-sight or cause it to lock on to the ground.

c. Dispense a pattern of 3 flares at 0.25 second intervals immediately after starting the break and also dispense chaff as there is a possibilty that the missile may be RF-guided or fuzed. To dispense both, select CP which in TOR07 gives Flare Program 2 (3 flares at 0.25 seconds) and Chaff Program 4 (one second of chaff at 20 mm/s).

d. If after having taken the above actions the missile remains on a collision course, repeat the actions at sub paras a and b above.

e. Once the first missile has been defeated look for the second! Be prepared for the fighter to manouvre for a further attack.

28.(S) **Considerations during IR Missile Engagements.** Despite the above rules for defeating an IR missile, several points need to be elaborated, namely:

a. Consideration should be given to the selective jettison. (See also para 9).

b. It is vital to carry out the counter to a fighter early so as to deny acquisition prior to missile launch, or to deceive the missile during its initial fly-out phase.

c. If RHWR indications or a very early visual spot indicate a CAP ahead, crews should re-route to avoid detection.

d. If crews make a late spot of CAP, they should assess whether the fighter is threatening before reacting. If it is believed that the fighter crew have not seen them, crews should buster out in a straight line and not risk exposing themselves by turning.

e. If the fighter threatens, turn to deny displacement by passing as near to 180° as possible bearing in mind aircraft weight, manoeuvrability, terrain screening etc. Crews should select idle/idle until within minimum missile range.

f. If fighter approaches from head-on, if possible, carry out counter to port to unmask the flares.

g. If fighter threatens from the beam, carry out counter.

h. If fighter ends up in the stern, but out of maximum missile range, he will do anything to reduce the range deficit by making the target turn. Examples are that he will lock the target on radar or even fire a missile outside its maximum range in the knowledge that the target will probably break or turn. If he has not fired, he is probably out of range or unable to achieve acquisition for another reason. Therefore, crews should continue to try and out-run the fighter, rather than breaking towards him and solving his range/acquisition problems. This is especially pertinent in formation where a fighter is unlikely to remain behind a single member of a package for protracted periods.

i. Should the missile counter fail, crews may have sufficient aircraft energy available to carry out an 'end game' 3-dimensional barrel roll manoeuvre towards the missile using maximum 'g' available.

29.(S) **SA Missile Threat.** The SA missile provides a capability of engaging a target when beyond visual range (BVR) particularly from the front hemisphere. It is unlikely that the pulse radars fitted to older generation Soviet made fighters have the capability to lock-on to a head-on target flying at low level. However, FLOGGER G, FOXHOUND A, FULCRUM and FLANKER are examples of possible threats assessed as having a head-on attack capability as they are fitted with pulse-doppler (PD) radars and head-on capable SA missiles; therefore in the event of a steady RHWR indication from an AI radar the crew must assume that their aircraft has been detected and take evasive action.

a. **SA Missile/AI Radar Characteristics.** Air-to-air SA missiles require the target to be illuminated by the threat aircraft, using either the AI radar or a separate illuminator. In general, PD radars are most effective head-on (ie high doppler difference) and are not affected by low level operations; the Pulse radar is effective from all aspects but its performance is severely degraded by ground clutter, particularly at low level. It is essential therefore to determine whether the locked-on threat is PD or Pulse.

Sub-para b next page.

b. **PD Aircraft/Missile Threat.** Should a PD threat warning occur the most effective counter is to fly tangentionally to the threat (ie beam the threat) and dispense chaff for the reasons given at Section 4 Chapter 3. Such a manoeuvre will enhance the IR radiation but if beyond visual range the effect is minimal. If the PD lock is broken it should then be possible to revert to the original track. Although further evasion should be taken if a relock occurs, it is probable that in the front hemisphere case the threat will then be too close to effect a successful SA missile firing.

c. **Pulse Threat.** A pulse locked-on threat should be evaded by flying as low as possible and, if the attack is from ahead, then a turn should be made to place the threat a minimum of 30° off the nose to minimise the chances of a subsequent visual detection. Chaff should be used as a means of breaking lock, or in the case of some missiles to cause premature fuzing. As stated in Section 4 Chapter 3, the Sky shadow counters against the older ex-soviet radars are not recommended.

30.(S) **Gun Threat.** Although snap, high deflection shots cannot be discounted, it is more likely that the gun will be used from the rear hemisphere, probably within a cone of semi-angle 30°, at short range and at less than the minimum missile range. However, to be effective, the gun must be aimed accurately and this is very difficult against a target flying very low, and jinking to negate the gun-aiming tracking solution. (Jinking should ensure flight path changes of at least 20° with manoeuvres timed to prevent a tracking solution being held for greater than the time of the flight of the bullet - approx. 2 secs).

31.(S) **Threat and Missile Avoidance.** Given time to analyse the behaviour of an enemy fighter which has been detected in the front hemisphere, it may be possible to determine whether or not the fighter is on a collision course. If the fighter is crossing ahead and appears not to have sighted the formation, a turn may allow the formation to gain some lateral separation and pass behind the threat. This will decrease the overall chance of the fighter gaining contact and increase his roll-out range should he acquire the formation. However, the visual acquisition of a FLOGGER size fighter is unlikely to occur outside 2 nm head-on, unless conditions are very favourable, eg cloud background or RHWR directed information.

32.(S) **Attack Confirmed.** As the fighter is seen to close, aircraft should normally turn hard towards a fighter in the front hemisphere (between 10 and 2 o'clock) to deny turning room for the conversion to the rear hemisphere. The exception is a locked-on PD threat radar beyond 2 nm as such a manoeuvre will enhance radar tracking and enhance SA AAM performance. Fuel permitting, and bearing in mind the enhancement of IR signature, the use of reheat should be considered to accelerate and so exacerbate the fighter's problem.

33.(C) **Tornado Performance.** The Tornado in a heavy-weight configuration has a very limited manoeuvring potential; any hard manoeuvring without reheat causes a dramatic loss of speed and a further reduction of manoeuvring ability. A threatened aircraft should therefore plan to use high speed, very low level flight with terrain screening, ECM, chaff and IRDs in an attempt to evade and escape. To assist a threatened aircraft to escape, thought should be given to providing mutual support within a formation. Formation elements in trail are best placed to provide this support by threatening the fighter with AIM-9L. The No 2 of the threatened pair may need to turn for a beam AIM-9L shot if support from astern is not available. It should be noted, however, that Trial

- MINIATURE found that any heavyweight manoeuvre resulted in excessive speed loss, thus only straight line tactics are feasible initially. If "last ditch" break manoeuvres are contemplated, jettisoning bombs and tanks (SEL JET) would provide approximately 30% increase in instantaneous turn performance and result in a similar reduction in energy loss. However, it must be emphasised that even a clean, lightweight Tornado will be unable to out-turn modern fighters. The probability of the destruction of the threatened aircraft when employing the tactic of runningfast and low will depend upon many factors, including IR signature, missile performance, ground clutter, skylining when ridge crossing, flare effectiveness and the extent of assistance from formation members. Previous experience has shown that tactics may need to be revised in the light of current wartime experience, thus a variety of tactics should be practised in peacetime training to allow the employment of alternate tactics should those chosen prove to be ineffective in war.

DEFENSIVE WEAPONS - SIDEWINDER AAM

SEE TAC MEMO No 2.

34.(C) The Tornado GR Mk 1's Air-to-Air (AAM) control system can be used to fire either 'G' or 'L' variants of the Sidewinder. Three modes of missile aiming can be employed utilising two different HUD displays and involving selections on Weapon Control Panel 2 (WCP 2), throttles, Pilot's Hand Controller (PHC) and control column. As missile firing is a complicated procedure, and as pilots are normally offered only fleeting opportunities to fire a Sidewinder, it is essential that the optimum techniques are employed. The information offered in this Annex is complementary to, and should be read in conjunction with CD-101B-4101-15B (Supplement to the Aircrew Manual Book 2).

35.(C) **Ground Check.** Currently, there is only one way to carry out a positive check of missile cooling and audio. After a successful WPU bite, ensure the MASS is at STBY and the Butt Test Switch is selected to TEST, then select Air-to-Air Override (AAO) twice to enter missile acquisition mode. This will provide cooling to both missiles and enable the audio channel. Adjust the MSL volume and check each missile in turn for correct IR detection functioning. Following this check, ensure that the Butt Test Switch is reselected to NORMAL and cancel AAO.

36.(C) **Missile Modes.** With the MASS at STBY or LIVE, the missile system may be operated in three different modes: Boresight (BRST), Scan (SCAN) and SLAVE (SLVE).

a. **Boresight Mode.** In BRST, the seeker head is fixed to the missile boresight, 25 mils (1.42°) below Longitudinal Fuselage Datum (LFD). In this mode the seeker field of view (FOV) is 3.6° (31 mils radius about the Viper Diamond (VD)).

b. **Scan Mode.** In SCAN, the centre of the seeker FOV is again fixed on the missile boresight, 25 mils below LFD. However, the head scans in a circular pattern radius of 0.9° superimposed on the normal BRST position. The VD will move in a small circle once per second and provide an effective FOV of 5.4° (47 mils radius about the centre of scan).

c. **Slave Mode.** In the SLVE mode, the seeker head is slaved to the reticule and is controlled either by the PHC or by the radar when locked on. As the reticule is slewed, the VD follows the movement and will enter the SCAN pattern when reticule movement stops, causing the VD to circle the reticule. In this mode the seeker heads can be slaved from boresight by up to 28.5° although the VD is limited to a maximum of 12° from the centre of the HUD (post Mod 942).

TACTICAL MEMORANDUM NO 2

DEFENSIVE WEAPONS - SIDEWINDER AAM

SIDEWINDER AAM

1.(C) The opportunity to fire a missile in anger will be, in all probability, a fleeting one. Not only is the switchery cumbersome, leading to missed opportunities, but it is an unlikely occurrence leading to a degree of surprise on the part of the crew. Consequently, the switchery must be practised and the different parameters committed to memory if any degree of success is to be achieved - remember your first live shoot at Aberporth? The information offered in this Tac Memo is complementary to, and should be read in conjunction with, CD-101B-4101-15B (Supplement to the Aircrew Manual Book 2). It replaces existing paras 34 to 52 of this chapter.

2.(C) **Ground Check**. Normally, the groundcrew will carry out a ground check to ascertain system. However, the following may be necessary. After a successful WPU bite, ensure the MASS is at STBY and the Butt Test Switch is selected to TEST, then select Air-to-Air Override (AAO) twice to enter missile acquisition mode. This will provide cooling to both missiles and enable the audio channel. Adjust the MSL volume and check each missile in turn for correct IR detection functioning. Following this check, ensure that the Butt Test Switch is re-selected to NORMAL and cancel AAO.

3.(C) **Missile Modes**. With the MASS at STBY or LIVE, the missile system may be operated in three different modes: Boresight (BRST), Scan (SCAN) and SLAVE (SLVE).

a. **Boresight Mode**. In BRST, the seeker head is fixed to the missile boresight, 25 mils (1.42°) below Longitudinal Fuselage Datum (LFD). In this mode the seeker FOV is 3.6° (31 mils radius about the VD).

b. **Scan Mode**. In SCAN, the centre of the seeker FOV is again fixed on the missile boresight, 25 mils below LFD. However, the head scans in a circular pattern radius of 0.9° superimposed on the normal BRST position. The VD will move in a small circle once per second and provide an effective FOV of 5.4° (47 mils radius about the centre of scan).

c. **Slave Mode**. In the SLVE mode, the seeker head is slaved to the reticle and is controlled either by the PHC or by the radar when locked on. As the reticle is slewed, the VD follows the movement and will enter the SCAN pattern when reticle movement stops. In this mode the seeker heads can be slaved from boresight by up to 28.5° although the VD display is limited to a maximum of approximately 12° from the centre of the HUD.

4.(C) **HUD Modes**. AUTO mode is recommended for the following reasons:

a. AUTO is the normal mode selected during flight. The extra switchery to select DIRECT is considered undesirable for snap-shot air-to-air opportunities.

b. AUTO provides an accurate display of target range with radar lock, which may be important for missile shots taken at the edge of missile performance. DIRECT gives no such information.

5.(C) **Sight Handling**. Air-to-Air sight handling is dependent upon missile mode selection as follows:

a. **BRST**. In BRST, the VD is positioned 1.42° below LFD, which places it approximately 2° - 3° above the flight path. To obtain a missile 'growl' it is necessary to hold the VD on the target, often for some time, causing the aircraft flight-path to drop below the target sightline. This is the least preferred of the modes for low level since the aircraft nose has to be precisely positioned for the missile to acquire the target. At low level this can lead to sighting with a lowering flight-path with the consequent danger of hitting the ground. At medium level, where the best defensive manoeuvre might be to fly a 180/0 at idle power, the use of BRST may well be the best option.

b. **SCAN**. In SCAN, the VD, and hence the seeker head, is rotated about the BRST position, increasing the field-of-view of the missile from a 3.6° to a 5.4° cone. This provides little advantage over the BRST mode, and occasionally, for a small distant target, seeker head rotation may cause the source to be out of field-of-view when AAO is pressed for IR lock necessitating a re-selection. Therefore, this mode is not recommended.

c. **SLVE**. The most flexible mode is SLVE with the VD scanning around the reticle position. The ability to slave the missile off-boresight allows the Tornado to remain at low-level whilst engaging a target at a different height. Additionally, with an EV3 radar in AAS the target can be "handed" to the pilot, after radar acquisition, by selecting BOGEY, thereby enhancing the probability of a successful engagement.

6.(C) **Missile Selection**. Cooling for the missiles is selected when the MSL ARM button on WCP 2 is pressed. The missile head may take up to 25 seconds to reach maximum cooling. A less than optimally cooled missile may preclude a valid shot opportunity. If a missile is pre-selected, the mode for acquisition may also be pre-selected. If no pre-selections are made, both missiles are selected and cooled after the second press of AAO and, if a mode has not been pre-selected, BRST will be selected automatically. Acquisition will not be possible before the missiles have cooled down, thus it is imperative that both missiles are pre-selected before entering a threat area. The AWC recommend that SLVE is pre-selected; this will obviate the need to go head-in to change modes if seeker head slew is required. To launch a missile, both the MASS and the Late Arm must be selected to LIVE prior to trigger press. **It must be stressed that if AAO is cancelled, with or without a valid shot having been taken, the missiles will be de-selected and cooling will cease until their re-selection.**

7.(C) **Auto Function.** On selecting AAO, with 2 missiles loaded, the SEL lights will both illuminate indicating cooling. The AAMU will then arm one missile, the SEL light will go out and the READY light will come on. Both missiles are now tied to look in the same direction and the missile that fires will be decided by the AAMU, depending upon the obscuration and audio level of each missile. If the armed missile seeker head enters an area where the airframe obscures the target, the AAMU will disarm it and arm the other missile; the lights on the MSL ARM buttons will reflect this change. If only one missile is pre-selected, or if one of the MSL ARM buttons is pressed after AAO, this handover function cannot operate.

Note: There is some doubt as to whether this facility will function correctly. The GAF has had several instances when, irrespective of the fact that the right missile was indicating armed and tracking, the left missile always fired on trigger press. If this missile has no valid IR source to track, or worse a friendly aircraft, then it will be wasted and a shot opportunity missed. It is intended to carry out a trial to confirm, or not, this phenomena.

8.(C) **Seeker Head Performance**. Many factors will influence missile firing success rate. Target range, over-take speed, IR intensity, background IR noise, countermeasures and crew training will all have a bearing on the probability of a kill. In all 3 missile modes, a missile can be fired either before, or after IR lock. When fired in acquisition, the seeker attempts to lock to the target in view at trigger press and self-track. Unfortunately, the tone heard at trigger press may not be present as the missile leaves the rail and attempts to self-track resulting in a wild missile. Therefore, AWC advice is that this method should only be used when firing from BRST. If an IR lock is obtained prior to launch, the seeker is disturbed by a CHIRP current which is designed to give confidence that the missile can sustain tracking. The level of irradiation required to sustain tracking through CHIRP is about twice the minimum level required to track normally after launch, and constitutes a very conservative confidence factor. Launch with a steady acquisition tone does not reduce the capability of AIM-9L in any way and a BRST "snap-shot", particularly at close range, should not be ignored.

9.(C) **Acquisition Boundary**. The major factors affecting the actual position of the target acquisition boundary are critical forward of the wing line. They are as follows:

a. **Target Engine Power**. Trials at low altitude have shown that the difference in boundary between an engine at max dry power and one at cruise can be more than 1 km.

b. **Engine Power Changes**. Trials have shown that the missile may lose lock if the target engine throttle is suddenly retarded, especially if accompanied by a break turn. A slam closure from Max Dry to Idle at greater than 3 km, or from Reheat to Idle at greater than 4 km, have been shown to break missile lock.

c. **Engine Exhaust Position and Shielding by Target Structure**. Jet pipe position and structure shielding create an "apple core" effect towards head-on aspects which is unique to a particular target at a particular power setting. The degree of range reduction can be quite severe over the last 30° of aspect towards the 180° point. Clearly at high aspects a target can break missile lock fairly easily with a small manoeuvre, especially if coupled with power reduction. For this reason, ideally, it is best to plan an attack to commence tracking behind the 150° aspect line.

d. **Atmospheric Absorption**. Atmospheric Absorption is worse at lower altitudes. With an in-flight visibility of 10 km, trials have shown that the transmittance at available wavelengths is 35% at 1,600 ft, increasing to 40% at 10,000 ft.

10.(C) **Single-Shot Kill Probability (SSPK)**. Trials have shown the following probabilities:

Probability:	
Serviceable pre-launch	0.85
Successful launch	0.97
Serviceable after launch	0.86
Guidance success	0.88
Proximity fuze	0.94
B class kill	0.95
Overall SSPK	0.55

11.(C) **Sight Handling**. As previously stated, a missile may be launched in either acquisition or lock-on, in any of the 3 modes (BRST, SCAN or SLVE). Whether or not an IR lock is attempted prior to launch initiation depends upon a number of factors:

a. **Launch in Acquisition**. The major advantage of initiating missile launch prior to lock-on is that it is simple. Having selected AAM mode point at the target, achieve a growl and squeeze the trigger. Note that it is necessary to continue to track the target after trigger press until the missile leaves the rails when it will self-track. A disadvantage is that the source of the growl may not be positively identified. Consequently, the shot may be lost to the edge of a cloud or another spurious, or friendly, IR source.

b. **Launch in IR Lock-on**. If IR lock-on has been achieved, the VD will indicate the point that the seeker head is tracking. This will enable clear identification of the IR source and allow re-designation if the missile has been seduced by flares, locked to a background hot-spot or a friendly aircraft. The fact that the missile is able to self-track provides a high confidence level that the missile will guide after launch. Pressing PH2 will enable a rapid radar lock to be achieved (since the radar in silent mode is always tied to the VD position), thereby giving range. With both the missile and the radar locked, it is possible to see and overcome the effect of countermeasures. If a flare decoys the IR lock away from the target, pressing AAO will put the missile back into acquisition and as the radar remains locked to the target, the VD jumps to the reticle enabling a second IR lock-on to be taken without having to re-slew the seeker head. Extreme care should be exercised when an IR lock has been achieved, but the VD position is off the side of the HUD as no confirmation of the lock position can be made with potentially disastrous results.

12.(C) **Ranging Cues**. With ASST 5.1 software, missile maximum and minimum range markers are displayed on the NTRC. The VD flashes when the target is within maximum and outside minimum ranges. The computations for an accurate Launch Success Zone (LSZ) are complex and take into account target/fighter mach differential, target range, launch height and OAT. It appears that the algorithm in Tornado GR1/4 may well be less than totally robust and may be making incorrect calculations. Experience has shown that with a valid self-track, the maximum LSZ displayed was only 4km in the front and beam - patently incorrect. Consequently, these **LSZ cues must be treated with caution**. A thorough knowledge of the capabilities and associated ranges of the AIM-9L must be used in the first instance, with the cues as a backup.

13.(C) **Harmonization**. Harmonization errors have been noted during trials. Firstly, random and unpredictable errors of up to 0.5° have been observed between missile boresight and VD position, due to variations in missile position following loading. Secondly, acquisition has proved difficult in BRST in turns greater than 2.5g and in SCAN or SLVE in turns greater than 3.5g due to aerodynamic effects moving the missiles with respect to the aircraft LFD. Therefore the VD may not indicate seeker head position precisely and this has the following effects:

a. The VD may need to be positioned slightly off-target to achieve an IR acquisition.

b. With an IR lock-on, in a hard-turning manoeuvre, the VD may track the target with an offset between VD and target.

Imminent (Dec 96) software will allow the crew to harmonize the VD position for each missile individually, thereby reducing the pointing errors to a minimum.

14.(C) **AIM-9L Employment - Summary**. Trials have indicated that the employment envelope for the AIM-9L is determined by IR acquisition in the front hemisphere and aerodynamic capability in the rear hemisphere. Hence, if an acquisition is obtained on a target between 180° and 120° Track Crossing Angle (TCA), a valid shot should exist provided the minimum range is not infringed. The fastest way to take a missile shot is to ensure the missiles are selected and cooled prior to an engagement, place the VD on the target, obtain an emphatic growl, visually assess the range and launch. If time permits, an IR lock-on should be attempted. An IR lock allows a positive check of missile tracking capability and which source is being tracked, the freedom to manoeuvre to a successful launch position and hence, an increased kill probability. However, a valid shot should not be prejudiced by the extra switchery and time required for an IR lock-on. It should be noted that to obtain an IR lock-on, it is necessary to press and hold the AAO button until the VD automatically follows the target and the growl changes to CHIRP. While the AAO button is depressed, the AAMU will not accept other signals and hence the AAO button must be released before trigger press or the missile will not fire. Also, so a second missile does not follow an unsuccessful missile, it is strongly recommended that the missiles are not ripple fired.

15.(C) **EV3 Radar**. Current radar standards enable the navigator to search for, and then track an airborne target. On pressing BOGEY, the target position is displayed on the HUD as a fixing cross. If AAO is pressed (with a valid missile and SLVE selected) then the VD will overlay the target and radar/IR lock should be rapidly achieved. However, this facility should not be mistaken for a true AI radar capability and undue reliance placed on it. MPCs have demonstrated a capability against a target in a look-up mode from low level, and a co-alt medium level target, but against a target at low level or slightly higher than the shooter, the radar has no tangible performance.

16.(C) **AIM-9L - Summary of Low Level Performance**. During flight, missile roll and gravity drop may cause the AIM-9L to fly below the **target** sightline. When fired against low-level targets (below 250ft) at long range (beam to head-on attacks), this can cause the missile to fuze and detonate on the ground. Caution need only be paid if attacking a target which is flying below 250ft, when the following rule of thumb should be applied:

a. For every 2km range from the target an extra 250ft should be added, above target height, prior to launch.

17.(C) In most practical cases, attacks will be carried out against targets flying above 250ft, in which case no allowance need be applied. This highlights the tactic of OLF as a robust defensive manoeuvre against many AAMs, whose flight profile or fusing system limits them against very low flying aircraft. The technique of "lofting" a missile, previously thought to improve the success of a low level firing, has been proved to be of no additional benefit. AWC advice is that no allowance need be made for target altitude unless it is below 250ft.

18.(C) **Suggested Techniques for the Operational Employment of the AIM-9L Sidewinder**. Listed below is a suggested sequence for the operational employment of the AIM-9L missile:

a. If possible obtain a missile cool-down and growl check on the ground.

b. Once airborne select each missile in turn and carry out the following:

(1) Check cool-down of seeker and set missile audio to the maximum volume without undue background noise.

(2) Lock onto an IR source and harmonize each missile in turn; **ensure weapon switches remain safe.**

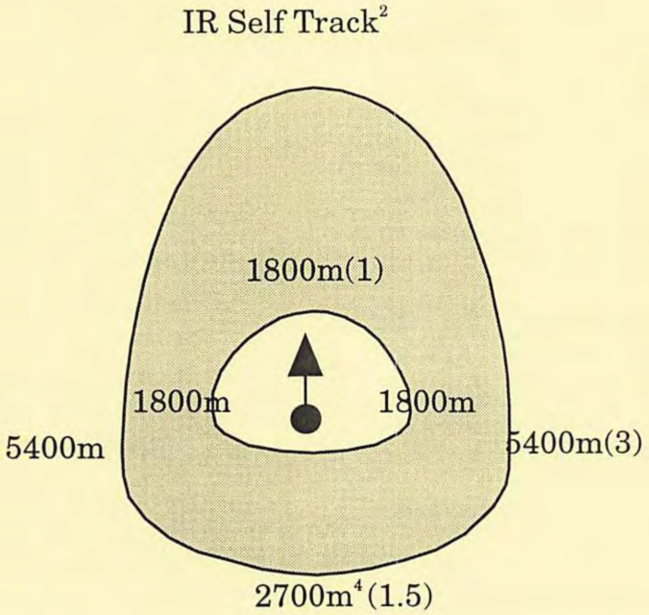
(3) Select both missiles and the preferred mode (SLVE) when approaching the threat area. If one missile does not perform correctly, or is unserviceable, deselect it.

(4) A rising audio level could indicate lack of cooling to one of the missiles. Isolate the faulty missile, deselect it and allow it to warm up for a few minutes before re-selecting. If the problem persists, deselect that missile.

(5) Select AAO twice and fly the VD over the target to obtain a growl. If there is sufficient time, attempt an IR lock. If the target is high, slew the VD rather than climb.

(6) If a rapid shot is essential in the head sector with AIM-9L fire on the growl. For other conditions check range first.

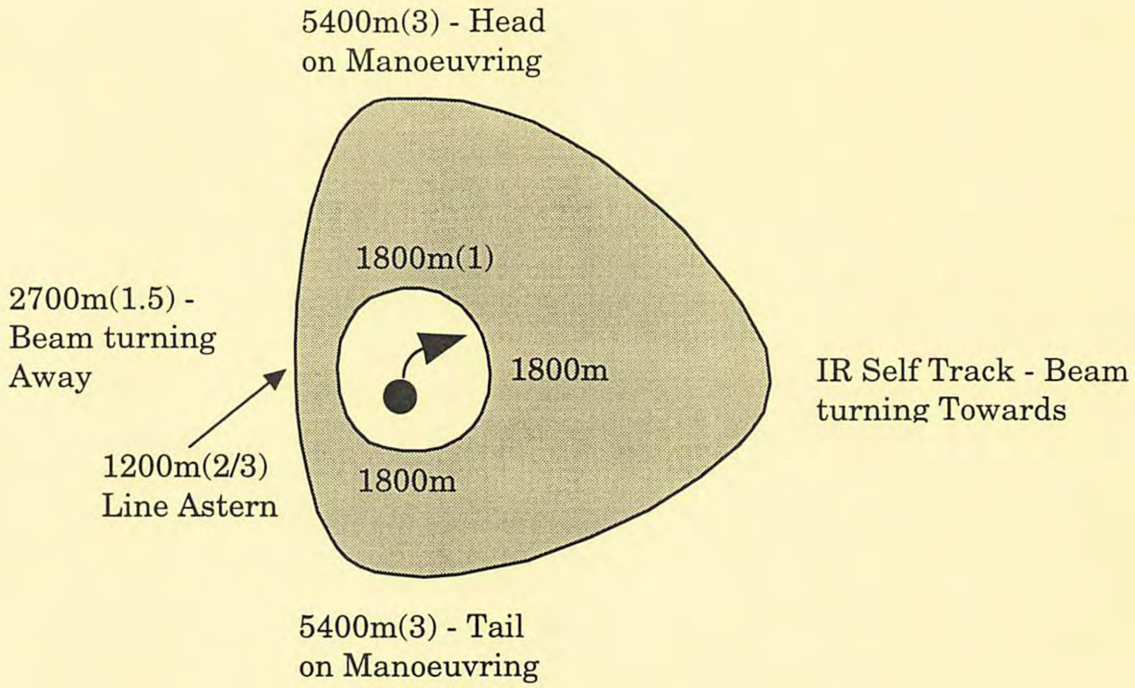
19.(C) **Launch Ranges**. Low level launch zone Rules of Thumb are given in Figs 6-2M-1 and 6-2M-2.



Notes:

1. Launch ranges assume valid IR self-track. IR acquisition boundary depends on aspect, power setting, background etc.
2. In the front hemisphere, IR acquisition and missile self-track is always inside the missile's aerodynamic range. If a valid self-track can be achieved outside minimum range, **fire**!
3. 300m direct line astern. Absolute minimum range firing may result in self frag! Add 300m/10° angle off target's tail (AOTT) up to a maximum of 50° AOTT.
4. 2700m at low level + 1800m/10000 ft up to a maximum of 9900m.
5. Figures in brackets are nautical miles.

Figure 6-2M-1 (C) - Maximum and Minimum Ranges for Aim-9L Against Non-Manoeuvring, Co-Speed, Targets



G Limits:	Aircraft Limits.	
Speed:	Aircraft Limits.	
Vertical Dispersion:	250ft agl/nm.	
Maximum Lag Angle at Launch:	25°.	
Time of Flight Allowance:	Head	3secs/nm.
	Beam	4secs/nm.
	Stern	6secs/nm.
Target dispensing Flares	Avoid line-astern firings. Fire from beam with minimum range. Wait for flares to cease.	

Figure 6-2M-2 (C) - Maximum and Minimum Ranges for Aim-9L Against Manoeuvring, Co-Speed, Targets

INTENTIONALLY BLANK

37.(C) **HUD Modes.** Whilst the two HUD modes, AUTO and DIRECT, provide similar information and facilities in the AAM format, the AUTO mode is recommended for the following reasons:

a. AAM and air-to-air guns (AAG) modes are linked and, as the AUTO AAG mode provides more facilities and is the easier display to handle, it is recommended that AUTO is used for missiles rather than carry out further switching to obtain DIRECT.

b. As air-to-ground weaponry is carried out in AUTO, this is the normal mode selected during flight. The extra switchery to select DIRECT is considered undesirable for snap-shot air-to-air opportunities.

c. AUTO provides an accurate display of target range with radar lock, which may be important for missile shots taken at the edge of missile performance parameters. DIRECT gives no such information.

38.(C) **Sight Handling.** Air-to-Air sight handling is dependent upon missile mode selection as follows:

a. **BRST.** In BRST, the VD is positioned 25 mils (1.42°) below LFD, which places it approximately 2° - 3° above the flight path. To obtain a missile 'growl' it is necessary to hold the VD on the target, often for some time, causing the aircraft flight-path to drop below the target sightline. Thus, this is the least preferred of the modes because the aircraft nose had to be precisely positioned for the missile to acquire the target and because of the dangers inherent in sighting with a lowering flight-path.

b. **SCAN.** In SCAN, the VD, and hence the seeker head, is rotated about the BRST position, increasing the field-of-view of the missile from a 3.6° to a 5.4° cone. This provides little advantage over the BRST mode, and occasionally, for a small distant target, seeker head rotation may cause the source to be out of field-of-view when AAO is pressed for IR lock. Failure to lock would necessitate restarting the switch sequence, and the subsequent time delay could result in a lost firing opportunity against a target approaching from the forward sector.

c. **SLVE.** The most flexible mode is SLVE with the VD scanning around the reticule position. The ability to slave the missile off-boresight allows the Tornado to remain at low-level whilst engaging a target at a different height.

39.(C) **Missile Selection.** Cooling for the missiles is selected when the MSL ARM button on WCP 2 is pressed. The missile head will be at operating temperature in less than 25 seconds. If a missile is pre-selected, the preferred mode for acquisition may also be pre-selected. If no pre-selections are made, both missiles are selected and cooled after the second press of AAO and if a mode has not been pre-selected, BRST will be selected automatically. Acquisition will not be possible before the missiles have cooled down, thus it is important to pre-select both missiles before entering a threat area. To provide the most flexible mode, it is suggested that SLVE is then pre-selected; this will obviate the need to go head-in to change modes if seeker head slew is required. To launch a missile, both the MASS and the Late Arm must be selected to LIVE prior to trigger press.

40.(C) **Auto Function.** The AAMU provides a system for selecting which missile will be fired. On selecting AAO, the SEL lights will both illuminate, indicating cooling. The AAMU will then arm one missile, the SEL light will go out and the READY light will come on. Both missiles are now tied to look in the same direction and the missile that fires will be decided by the AAMU, depending upon the obscuration and audio level of each missile. If the armed missile seeker head enters an area where the airframe obscures the target, the AAMU will disarm it and arm the other missile; the lights on the MSL ARM buttons will reflect this change. If only one missile is pre-selected, or if one of the MSL ARM button is pressed after AAO, this handover function will not operate and target tracking or audio could be lost. It is therefore recommended that both missiles are pre-selected and that the AUTO function is only overridden by manually selecting one missile if a fault occurs in the other missile.

41.(C) **Indication Problems**. In the HUD, the difference between the AAG and AAM modes is indicated by the presence of the VD in the latter case. However, the presence of a VD should not be relied upon as the sole indication of AAM mode as it can also be displayed erroneously should, for example, the TACAN have been selected off from start-up. The only indication of missile seeker head lock is by a change in the missile audio-tone. With audio inputs from radio, intercom, RHWR etc, this audio-tone change can be easily masked. Therefore, it is essential that the missile-tone volume is set sufficiently high.

42.(C) **Seeker Head Performance**. Many factors will affect missile firing success rate. Target range, over-take speed, IR intensity, background IR noise, countermeasures and crew training will all have a bearing on the probability of a kill. In all 3 missile modes, a missile may be fired either before or after IR lock. The AIM-9L IR detector cell is sensitive to IR in the range 3.8 to 4.85 microns. The primary source of energy in this band is the emission from hot CO_2 molecules in the target aircraft's engine exhaust plume radiating at 4.2 to 4.5 microns. When fired in acquisition, the seeker attempts to lock to the target in view at trigger press. Tracking capability is zero, on Boresight, with an irradiation of less than 15 pico watts/cm^2 (pico = 10^{-9}). At 35 pico watts/cm^2, the seeker can be expected to track adequately for launch in acquisition. The range at which this level of irradiation is available constitutes the acquisition boundary. However, no rule of thumb or automated system can predict this boundary; it must be determined empirically. Audio tone amplitude is inadequate as an indicator because the levels of irradiation concerned are very low and comparable to background radiation. If an IR lock is obtained, the seeker is disturbed by a CHIRP current which is designed to give confidence that the missile can sustain tracking. The level of irradiation required to sustain tracking through CHIRP is 50-70 pico watts/cm^2. This is about twice the minimum level required to track normally after launch, and constitutes a very conservative confidence factor. Launch on an acquisition tone does not reduce the capability on AIM-9L in any way and a "snap-shot", particularly at close range, should not be refused.

43.(C) **Acquisition Boundary**. The major factors affecting the actual position of the target acquisition boundary are critical forward of the wing line. They are as follows:

a. **Target Engine Power**. Recent trials at low altitude have shown that the difference in boundary between an engine at Dry Power and one at cruise power in the Dry range can be more than 1 km.

b. **Engine Power Changes**. Recent trials have shown that the missile may lose lock if the target engine throttle is suddenly retarded, especially if accompanied by a break turn. A slam closure from Max Dry to Idle at greater than 3 km, or from Reheat to Idle at greater than 4 km, have been shown to break missile lock.

c. **Engine Exhaust Position and Shielding by Target Structure.** Jet pipe position and structure shielding create an "apple core" effect towards head-on aspects which is unique to a particular target at a particular power setting. The degree of range reduction can be quite severe over the last 30° of aspect towards the 180° point. Clearly at high aspects a target can break missile lock fairly easily with a small manoeuvre, especially if coupled with power reduction. For this reason, though snap shots in this region should never be refused, it is best to plan an attack to commence tracking behind the 150° aspect line.

d. **Atmospheric Absorption.** Atmospheric Absorption is worse at lower altitudes. With an in-flight visibility of 10 km, trials have shown that the transmittance at available wavelengths is 35% at 1,600 ft, increasing to 40% at 10,000 ft.

44.(C) **Background Interference.** Increased seeker sensitivity in AIM-9L has the unfortunate side effect of increased susceptibility to background interference. Water reflection, white clouds and overland hot-spots will provide irradiation comparable to that produced by a target from the front hemisphere. The missile will readily lock to the background.

45.(C) **Capability against IR Decoy Flares.** In trials, AIM-9L transferred lock from a Dry power target to flares whenever angle off the tail exceeded 10° (dead line-astern), the missile held track on 58% - 80% of occasions. The seeker is not normally decoyed by flares when tracking a reheat plume.

46.(C) **Single-Shot Kill Probability (SSPK).** Trials have shown the following probabilities:

Probability:	
Serviceable pre-launch	0.85
Successful launch	0.97
Serviceable after launch	0.86
Guidance success	0.88
Proximity fuze	0.94
B class kill	0.95
Overall SSPK	0.55

47.(C) **Sight Handling.** As previously stated, a missile may be launched in either acquisition or lock-on, in any of the 3 modes (BRST, SCAN or SLVE). Whether or not an IR lock is attempted prior to launch initiation depends upon a number of factors:

a. **Advantages of Launch in Acquisition.** The major advantage of initiating missile launch prior to lock-on is that it is simple. Having selected missile mode, all that is required is to point at the target, achieve a growl and squeeze the trigger. No extra switch selections, transferring hands between the PHC and the throttles are required and no time is wasted in assessing missile self-track status. Note that it is necessary to continue to track the target after trigger press until the missile leaves the rails or else the missile is unlikely to guide successfully.

b. **Advantages of Launch in IR Lock-on.** If IR lock-on has been achieved, the VD will indicate the point that the seeker head is tracking. This will enable clear identification of the IR source that the missile would guide to and allow re-designation if the missile has locked to a background hot-spot or a friendly aircraft. The fact that the missile is able to self-track whilst in CHIRP mode provides a high confidence level that the missile will guide after launch. As the irradiance levels in Para 32 indicate, the same may not be true in acquisition. An obvious side benefit of the lock-on indications is that if flares are released by the target prior to launch and they seduce the seeker head, the VD will no longer track the target.

Once an IR lock-on has been obtained, the reticule is tied to the VD. Pressing PH2 will then enable a rapid radar lock to be achieved, easing the range assessment task. With both the missile and the radar locked up, it is possible to see and overcome the effect of countermeasures. If a flare decoys the IR lock away from the target, pressing AAO will put the missile back into acquisition and as the radar remains locked to the target, the VD jumps to the reticule enabling a second IR lock-on to be taken without having to slew the seeker head.

48.(C) **Harmonization.** Harmonization errors have been noted during initial trials work in two areas. Firstly, random and unpredictable errors of up to 0.5° have been seen between missile boresight and VD position, due to variations in missile position following loading. Secondly, acquisition has proved difficult in BRST in turns greater than 2.5g and in SCAN or SLVE in turns greater than 3.5g due to aerodynamic effects moving the missiles with respect to the aircraft LFD. Therefore the VD may not indicate seeker head position precisely and this has the following effects:

a. The VD may need to be positioned slightly off-target to achieve an IR acquisition.

b. With an IR lock-on, in a hard-turning manoeuvre, the VD may track the target with an offset between VD and target.

Despite these effects, a growl or CHIRP will indicate successful acquisition or lock-on and would not preclude missile launch.

49.(C) **AIM-9L Employment - Summary.** Trials have indicated that the employment envelope for the AIM-9L is determined by IR acquisition in the front hemisphere and aerodynamic capability in the rear hemisphere. Hence, if an acquisition is obtained on a target between 180° and 120° Track Crossing Angle (TCA), a valid shot should exist provided the minimum range is not infringed. The fastest way to take a missile shot is to ensure the missiles are selected and cooled prior to an engagement, place the VD on the target, obtain an emphatic growl, visually assess the range and launch. If time permits, an IR lock-on should be attempted. An IR lock allows a positive check of missile tracking capability and which source is being tracked, the freedom to manoeuvre to a successful launch position and hence, an increased kill probability. However, a valid "snap-shot" should not be prejudiced by the extra switchery and time required for an IR lock-on. It should be noted that to obtain an IR lock-on, it is necessary to press and hold the AAO button until the VD automatically follows the target and the growl changes to CHIRP. While the AAO button is pressed, the AAMU will not accept other signals and hence the AAO button must be released before trigger press or the missile will not fire. Also, so that a second missile does not follow an unsuccessful missile, it is strongly recommended that the missiles are not ripple fired.

50.(C) **AIM-9L - Summary of Low Level Performance.** During flight, missile roll and gravity drop causes the AIM-9L to disperse below the target sightline. When fired against low-level targets at long range (beam to head-on attacks), this can cause the missile to fuze and detonate on the ground return. A BAe modelling study has revealed minimum launch altitudes for various ranges, speeds and aspect angles and, for a M0.6 target, this equates to 250 ft agl. However, for example, a minimum launch altitude of 450 ft could be required if firing at 5 km on a 140° TCA. In this case, if range is increased to 6.5 km, the minimum altitude becomes 1,100 ft. The graph at Figure 6-2-1 provides further information. This low-level launch limitation may be overcome by using a pitch-up firing tactic.

51.(C) **Pitch-up Firing Tactic.** CTTO advice is to fire the missile with IR lock and to pitch the nose 5° above the true horizon prior to firing. Range should preferably be inside 6 km, because the required altitude for a successful intercept increases dramatically outside this range. If launch is necessary in BRST (ie late acquisition) then it should be completed co-altitude inside 4 km. Tactically, the Tornado should remain at low-level whenever possible. Launching with a pitch-up following IR lock, at ranges inside 4 km, should reduce exposure to the minimum whilst increasing the chances of a successful intercept.

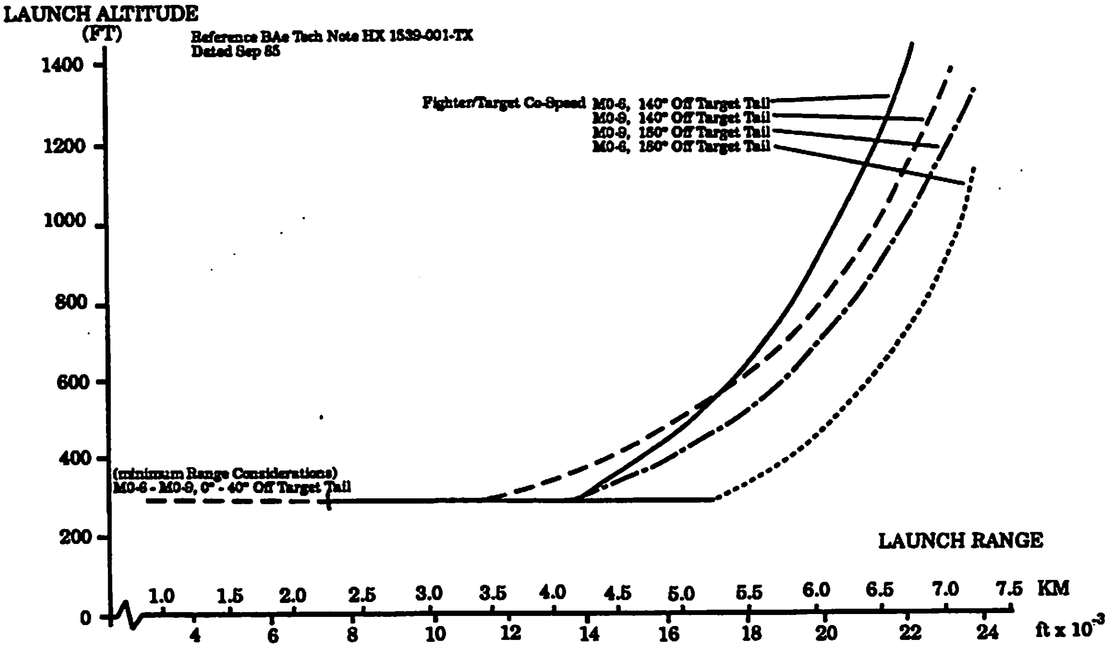


Figure 6-2-1 (C) - Minimum Launch Altitude for Successful firing against 250 ft Altitude Targets as a Function of Launch Range

52.(C) **Suggested Techniques for the Operational Employment of the AIM-9L Sidewinder.** Listed below is a suggested sequence for the operational employment of the AIM-9L missile:

a. If possible obtain a missile cool-down and growl check on the ground.

b. Once airborne select each missile in turn and carry out the following:

(1) Check cool-down of seeker and set missile audio to the maximum volume without undue background noise.

(2) Lock onto an IR source and note the individual seeker harmonisation; ensure weapon switches are safe.

c. Select both missiles and the preferred mode (SLVE) when approaching the threat area. If one missile does not perform correctly, or is unserviceable, deselect it.

d. A rising audio level could indicate lack of cooling to one of the missiles. Isolate the faulty missile, deselect it and allow it to warm up for a few minutes before reselecting. If the problem persists, deselect that missile.

e. If a missile shot is required, ensure the aircraft is positioned for the appropriate missile envelope (AIM-9G or AIM-9L).

f. Select AAO twice and fly the VD over the target to obtain a growl. If there is sufficient time, attempt an IR lock. If the target is high, slew the VD rather than climb. Remember the harmonisation errors.

g. If a rapid shot is essential in the head sector with AIM-9L fire on the growl. For other conditions check range first.

DEFENSIVE WEAPONS

53.(C) **Launch Ranges.** Launch zone Rules of Thumb are given below:

a. **Minimum Range**

(1). Stern: 0.3 km

(2) Beam: 1.2 km

(3) Front: 1.8 km

These ranges are "off-the-rail" values, they do not allow for the launch delay of about 0.5 secs but the stern value is valid for Co-speed targets.

b. **Maximum Range**

(1) Stern: 3 km

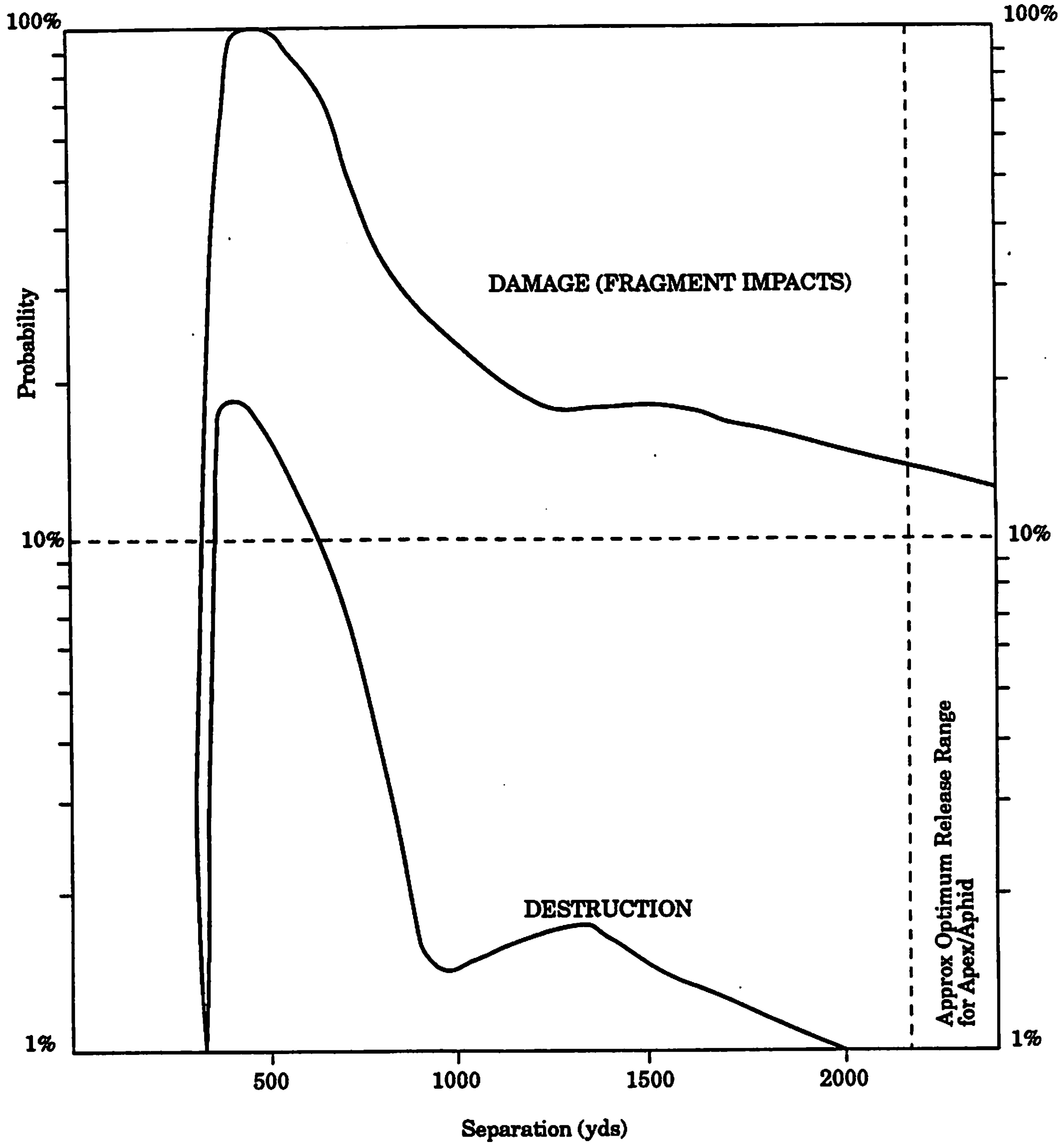
(2) Beam: 5 km

(3) Front: 7 km

For maximum ranges at higher altitudes add 2 km per 10,000 ft. Provided a steady "growl" is received and the target is within range, a successful missile engagement should result.

DEFENSIVE WEAPONS - BOMBS

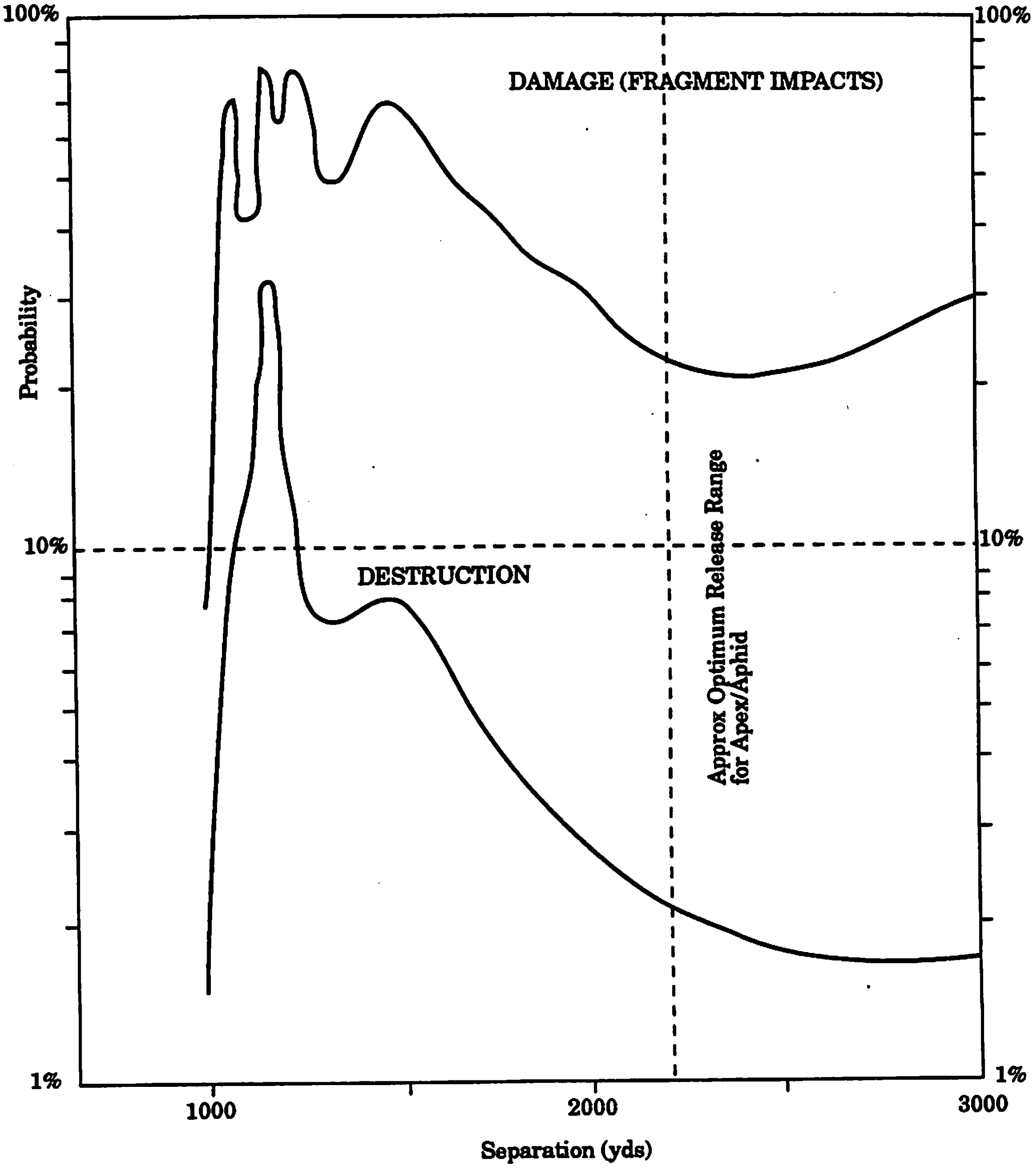
54.(C) **1,000 lb Retard Bomb.** If a crew find themselves threatened by an enemy fighter and cannot prevent the enemy from closing in the 6 o'clock position, consideration should be given to releasing a weapon 'live'. A retard bomb can be used as an effective self-defence weapon with fragments from an exploding bomb forming a defensive screen behind the aircraft. The 10,000 or so fragments from a 1,000 lb bomb are ejected with an initial velocity of up to 6,000 ft/sec; larger fragments stay in the air for up to 30 seconds, reaching heights up to 3,000 ft. Although in level flight at low level there is little likelihood of destroying attacking aircraft there is a good possibility of damaging a pursuing fighter and a near certainty that the pilot will be forced to take an evasive manoeuvre or be distracted. The major difficulty in employing this tactic is the estimation of range of the aggressor behind the Tornado. Range estimations should therefore be executed by the wingman of the threatened aircraft, who should make a 'KNICKERS' call when the fighter is at vulnerable range. Since the object of the tactic is to prevent missile launch by distracting or damaging rather than destroying the attacker, an early rather than late 'KNICKERS' call is recommended (see Figure 6-2-2). A missile stern shot from approximately 2,000 yds would seem likely and based on this and the need to distract or damage, a 'KNICKERS' call when the attacker is 2,500 - 3,000 yds in trail is recommended. There will be a greater chance of inflicting damage on the trailing aircraft at that range if the weapon is released in a 5° climb (Figure 6-2-3), but against this must be considered the risk of giving a "blue sky" shot. The advantages of distracting the attacking pilot are not limited solely to the time of explosion of the retard bomb, but should also include the time taken for that pilot to take avoiding action and visually re-acquire a fast receding camouflaged low-level Tornado. If the Tornado is turned in the opposite direction to the fighters manoeuvre then the separation distance can be effectively doubled, as depicted in Figure 6-2-4.



TORNADO (Level Flight) : 540 knots; 150 feet

FLOGGER (Level Flight) : 590 knots; 350 feet

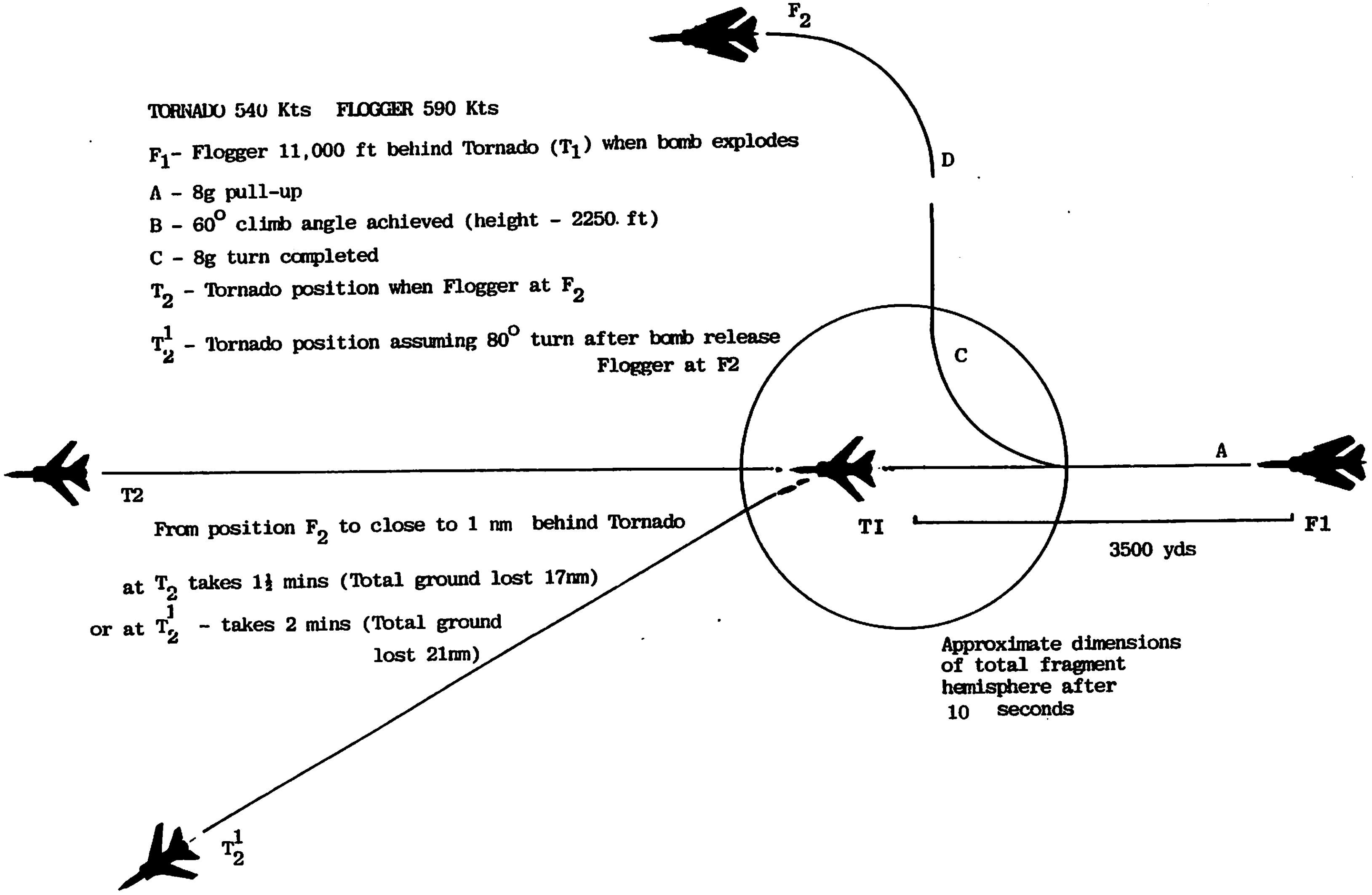
Figure 6-2-2(C) - Probability of Damaging a Pursuing Aircraft with a 1,000 lb Retarded Bomb



TORNADO (5° Climb): 540 knots; 150 feet

FLOGGER (Level Flight): 590 knots; 350 feet

Figure 6-2-3(C) - Probability of Damaging a Pursuing Aircraft with a 1,000 lb Retarded Bomb Released in a 5° Climb



TORNADO 540 Kts FLOGGER 590 Kts

F_1 - Flogger 11,000 ft behind Tornado (T_1) when bomb explodes

A - 8g pull-up

B - 60° climb angle achieved (height - 2250 ft)

C - 8g turn completed

T_2 - Tornado position when Flogger at F_2

T_2^1 - Tornado position assuming 80° turn after bomb release Flogger at F2

From position F_2 to close to 1 nm behind Tornado

at T_2 takes 1½ mins (Total ground lost 17nm)

or at T_2^1 - takes 2 mins (Total ground lost 21nm)

Approximate dimensions of total fragment hemisphere after 10 seconds

Figure 6-2-4(R) - Possible Effect of the Release of a 1,000 lb Retarded Bomb on a Pursuing Aircraft

The parameters in Figure 6-2-4 are for an ideal case, but do represent the possible effect of the tactic which could result in a trail distance of 3 or 4 nm - a difficult range for visual re-acquisition - requiring, at 100 kn overtake, a 1 min to $1^1/2$ min chase to achieve a kill solution. Retard defence is a feasible defensive tactic, its two major limitations being the loss of an attack weapon and the fact that the tactic can only be employed if retard weapons are carried. Therefore, whenever retard weapons are carried, one of the weapons packages selected at WCP 1 should be for one bomb only. Therefore, during transit if retard defence is required, selection of TOO will enable its rapid release.

55.(C) **CBU Defence.** The possible use of the CBU as a means of defence against an enemy fighter has been investigated. The highest probability of destroying a following aircraft, about 20%, is associated with very small separation distances (100-200 feet) and very low heights (of the order of 100 ft AGL). For separations greater than 800 ft, the probability becomes insignificant. Therefore, there may appear to be little merit in using the CBU as a damage weapon, however, it is important to realise that any store release, including wing tanks, could severely distract an attacking pilot.

SUMMARY - FIGHTER THREAT

56.(S) **Tactics - Basic Concepts.** Tactics to counter the air threat depend upon many factors; they could vary from running in a straight line as low and as fast as possible, to carrying out positive offensive action against any fighter threat as soon as it is acquired. When devising a set of tactics, the following basic concepts should be considered:

a. No single set of tactics will provide a defence in all situations.

b. To be effective, a set of tactics must be simple, not too difficult to fly, and above all, must be practicable and practised.

c. A Tornado, even in a lightweight configuration, will not out-turn a modern fighter.

d. An aircraft that is threatened will not be able to defeat that threat with its own forward firing weapons.

e. Combat fuel allowances may be so small that evasion may have to be severely limited if the target is to be attacked and the aircraft are to return to home base.

f. When in an air threat environment, the formation dimensions should be optimised to enable the effective employment of AIM-9L in mutual support.

g. When positively threatened by another aircraft, all other potential threats become of secondary importance.

h. The peacetime development of evasion tactics and training should be comprehensive so that in the event of war the most effective tactics can be adopted; day two of the war is not the time to develop new tactics.

57.(S) **Recommended Tactics.** The ability to recognise the degree of threat posed by a fighter requires an extensive knowledge of its potential capabilities and experience in evading attacking aircraft. The most common mistake is to over-react to an insignificant threat and unnecessarily jeopardise the success of a mission. If radio silence is in force, the threat should be watched and only reported if it appears to be closing. Fighter tactics may be to use slashing attacks with aircraft in trail to break the formation and cause aircraft to jettison their weapons. There is no panacea - especially if the threat of fighters equipped with mixed IR and SA missiles having an all-aspect capability. Nevertheless it is possible to devise recommended tactics for a given situation; all require a descent to very low level as the first priority. The following tactics are recommended for a pair of aircraft flying in defensive battle formation:

a. At all times when a fighter is detected, BUSTER to Max Dry powerand check Knickers package

b. **Front Hemisphere**

(1) Beyond Visual Range, CW Lock On - turn so as to place the threat at 90°, then return to track once lock-on has been broken.

(2) Beyond Visual Range, Pulse Lock-on - turn to place the threat a minimum of 30° from the centre line - the turn should be in the direction to pass behind the threat.

(3) If threat is visually acquired:

(a) Turn to pass behind to avoid detection.

(b) If the fighter turns in, turn to put it head on and consider an AIM-9L engagement (Max 7 km with IR lock) and consider Head-on Knickers option.

c. **Beam Position.** An attack from the beam is the most difficult situation in non-visual conditions for both attacker and defender; it is likely to be converted to a stern attack. In visual conditions the Tornado should:

(1) Terrain screen to avoid detection.

(2) If detected and time allows, Tac-turn the element/formation 90° towards the fighter for a head-on AIM-9L engagement or, if time is short, counter the inside aircraft towards the fighter. If sufficient energy throttle back to idle-idle for IRCM.

(3) If an IR missile launch is detected flares and chaff should be dispensed whilst initiating a defensive break.

d. **Rear Hemisphere.**

(1) In non-visual conditions, when lock indicated on RHWR (Trial ENSTATE) turn to put threat at 90° and use combined programme.

(2) In visual conditions:

(a) Widen the formation to 2 nm (NB. Trial MINIATURE for AAM support from laterally spaced aircraft).

(b) When one aircraft is positively threatened it should use the combined programme facility for chaff and flares, and if possible employ retard defence on a call from the wingman. (The latter could, if the situation dictates, cross the formation to threaten the fighter with an AIM-9L).

(c) If missile launch is detected, flares should be dispensed combined with a hard manoeuvre, preferably to port. (Trial ENSTATE).

(d) If the fighter closes into guns range, an unpredictable jink should be flown with turns of at least 20°.

(e) As a last ditch action a BREAK should be used and stores jettisoned (ensuring selective jettison is used so as to retain the missiles and BOZ and Skyshadow pods).

58.(C) Finally, it must be emphasised that any set of tactics to be employed must be based on the overriding requirement to get as many aircraft as possible to the target - and return for further tasking.

SURFACE-TO-AIR GUN SYSTEMS

INTRODUCTION

1.(R) This Annex contains a discussion of the surface-to-air anti-aircraft artillery (AAA) environment to be expected by aircrew during combat deployment. The first part of the discussion describes weapon characteristics and types of gunfire control which may be found in most threat scenarios. The remainder of the discussion covers land-based and shipborne systems and lists the weapons and describes the fire control radars that may be confronted in each environment.

2.(C) Enemy artillery (land-based) or guns (shipborne) that pose a surface-to-air threat may be grouped into four categories:

a. AW (Automatic weapons), usually of 14.5 mm and less, all have an extremely high rate of fire and use on-carriage open or optical type sights for fire control.

b. LAA (light anti-aircraft), consisting of weapons ranging from 23 mm to 57 mm, use a wide variety of fire control devices or systems.

c. MAA (medium anti-aircraft), consisting of 76.2 mm and 85 mm weapons controlled by off-carriage radar and/or optical fire control systems.

d. HAA (heavy anti-aircraft), consisting of 100 mm and 130 mm weapons controlled by off-carriage radar and/or optical fire control systems.

3.(C) A land based off-carriage fire control system (radar and/or optical) can provide pointing orders to an AAA battery of up to 8 guns if the system is within approximately 300 yds of the AAA site. A shipborne fire control system normally can control more than one AA (anti-aircraft) gun, the number depending on the location of the gun mounts relative to the fire control system.

4.(U) For simplicity, the terms AAA or guns will be used interchangeably in the remainder of the text regardless of the location of the weapon system (land-based on shipborne).

GUN SYSTEMS

5.(S) The overall characteristics of gun systems are shown in Table 6-2A-1. In general, most shipborne guns are twin mounts, while for land-based guns, the number of barrels tends to decrease as the calibre increases. The 30 mm guns and the 45 mm to 85 mm guns are expected to be the most effective for directing accurate and sustained rates of fire against aircraft. However, there is some evidence that excessive heating, particularly with the land based 57 mm gun, precludes sustained firing. This would limit the 57 mm to approximately 50 rounds with a 1 to 3 minute cooling off period. The smaller calibre weapons provide a relatively good short range protection against aircraft due to their RATE OF FIRE ~~high fire power characteristics~~. The larger calibre guns, 100 mm and 130 mm, are generally not capable of directing accurate fire against high performance aircraft, especially if mild manoeuvres are employed.

6.(R) A reduction of the maximum rate of fire is normally the result of one or more factors: excessive heating, magazine capacity, and/or manual loading rate.

AL2 (MS)

Weapon Calibre (mm)	Class	Max Hor Range (nm) (See Note 1)	Max Vert Range (ft) (See Note 1)	Platform	Rate of Fire RNDS/BRL/MIN)		Type Fire Control	Elevation Limits (Deg)	Mount	Reaction Time (Sec) (See Note 2)
					Max	Practical				
12.7	AW	3.5	14,400	Land	600	80	OS	-10 to 85	S/Q	8
				Ship	600	150*	OS	-5 to 85	T	
14.5	AW	3.5	16,400	Land	600	150	OMC	-10 to 90	S/T/Q	8
				Ship	600	150	OMC	-5 to 85	T	
23	LAA	3.8	16,400	Land	1000	300-350	OMC RDR/OPT COMP	-10 to 90	T/Q	8 (OMC) 15 (COMP)*
25	LAA	3.9	14,700	Ship	240	100*	OMC RDR/OPT COMP	-10 to 85	T	8 (OMC) 15 (COMP)*
30	LAA	5.5	23,000	Land	450	100*	OS	-10 to 90	T	8
				Ship	550	150*	RDR/OPT COMP	-10 to 100	T	15*
37	LAA	4.4	19,700	Land	180	80	OMC	-5 to 85	S	10
				Ship	180	80	OMC	-10 to 85	T	
45	LAA	6.3	25,000	Ship	130	80*	RDR COMP	-4 to 90	Q	30
57	LAA	6.6	24,300	Land	120	70	OMC RDR/OPT COMP	-4 to 87	S/T	8 (OMC) 20 (COMP)*
				Ship	120	75	OMC RDR/OPT COMP	-5 to 90	T/Q	8 (OMC) 20 (COMP)*
76.2	MAA	8.5	45,000	Ship	90	40*	RDR/OPT COMP	-10 to 85	T	20
85	MAA	9.0	46,000	Land	20	15	RDR/OPT COMP	-3 to 82	S	30
				Ship	20	15	RDR/OPT COMP	-10 to 90	T	
100	HAA	11.5	48,000	Land	15	15	RDR/OPT COMP	-3 to 87	S	30
				Ship	18	15	RDR/OPT COMP	-8 to 85	S/T	
130	HAA	16.0	72,000	Land	12	12	RDR/OPT COMP	-5 to 80	S	30
				Ship	12	12	RDR/OPT COMP	-5 to 85	T	

Note:

1. Tactically effective range for a non-manoeuvring target is approximately 1/2 (or less) the maximum range. The range for a high speed, manoeuvring target is reduced again by 50 to 75 percent.
2. Reaction time is the mean time between detection and commencement of fire

Legend:

OS - Open Sight
OMC -Optical Mechanical Computing (Normally On-Mount)
RDR - Radar
OPT - Optical
COMP - Computing
S - Single
T - Twin
Q - Quad
* Estimate

Table 6-2A-1(S) - Gun System Characteristics

7.(S) Maximum ranges given in Table 6-2A-1 represent maximum trajectory capability and do not represent effective range against high performance aircraft. The tactically effective range is generally one-half or less of the maximum range.

8.(S) **Projectiles.** The characteristics of projectiles used in gun systems are summarized in Table 6-2A-2. As a general rule, shells that burst with white puffs are contact-fuzed 57 mm or smaller and are detonated by a fixed-time, self-destruct powder train, while shells that burst with black puffs are larger than 57 mm and may be burst by MT (mechanical timed) fuzes. Note that initially when an RDX loaded shell bursts, the debris is yellow-orange but rapidly becomes a mixture of white and black clouds so that pilots see these bursts as greyish-white. Shells equipped with PD (point detonating) fuzes actuate on contact with some surface of the aircraft and then, with some delay, explode inside the aircraft structure. They may, in addition, be exploded in the air by a self destruct fuze powder train. Larger calibre shells are normally equipped with MT fuzes to burst the shell in the air and produce damage by fragment impact. These shells also have contact fuzing so that a shell striking an aircraft will explode. It is believed that the Soviets have developed VT (proximity) fuzes in addition to MT fuzes. However, no evidence exists to indicate the use of VT fuzes outside of the Soviet Union. The disadvantage of the MT fuze is that dispersion of burst along a given trajectory about a predicted target position is quite large, when compared to the dispersion of the shells about the same target.

Calibre (mm)	Type Fuze (Note 1)	Self Destruct Time (Sec)	Self Destruc (Range (ft)	Weight (lb) (ft/sec)	Muzzle Velocity	Filler	Burst Colour	Tracers
12.7	-	-	-	0.1	2,800	-	-	Yes
14.5	-	-	-	0.14	3,300	-	-	Yes
23	PD	5 to 11	12,500	0.4	3,050	TNT	Black	Yes
25	PD	About 11	UNK	0.65	2,980	TNT	Black	Yes
30	PD	About 11	UNK	0.92	3,280	TNT	Black	Yes
37	PD	9 to 11	14,700	1.6	2,900	TNT o RDX	Grey o White (Note 2)	Yes
45	PD	About 16	UNK	3.2	3,300	UNK	-	Yes
57	PD (Note 3)	15 to 18	28,900	6.3	3,300	RDX	Grey or White (Note 2)	Yes
76.2	PD	About 20	UNK	20.2	3,210	UNK	-	No
85	MT, PD (Note 3)	30	34,00	21.1	2,600	TNT	Black	No
100	MT, PD	28 to 32	50,000	34.6	3,000	TNT	Black	No
130	MT, PD+VT	-	72,000	73.6	3,100	HE	Black	No

Notes:

1. PD = Point Detonating, MT = Mechanical Time, VT = Proximity.
2. Technical yellow-orange at instant of burst but assumes a greyish-white appearance a fraction of a second after burst.
3. Possible VT capability.

Table 6-2A-2 (S) - Projectile Characteristics

9.(S) **Types of AAA Fire Control.** Due to limitations produced by the nature of the equipment, speeds of targets, visibility, etc, several methods of controlling the fire of many guns defending an important target may be used, depending on the tactical situation. Three primary methods of control may be distinguished: aimed, sector intercept and barrage fire control.

AIMED FIRE

10.(S) Fire is directed at a target or group of targets utilizing the fire control mode of the equipment available to the pertinent gun system. This type of fire requires optical or radar detection of the target and sufficient delay time for operator or computer settling and then, after commencement of fire, sufficient projectile time of flight to obtain first intercepts. Aimed fire can be continued along the flightpath of the aircraft until the aircraft passes out of range. The maximum effective range for radar controlled weapons is normally determined by the maximum effective range of the projectile, established from estimates of accuracy and lethal radius of the projectile. For optically controlled systems, this range is determined by either the maximum effective range of the projectile, the optical tracking range, or tracer visibility. Aimed fire should be seriously degraded during the period in which an aircraft is manoeuvring. With typical predicting systems, the manoeuvre will introduce a bias into the shooting distribution. This bias, for manoeuvres of 2 g to 4 g, is sufficient to reduce the probabilities of a hit on an aircraft target to quite small values.

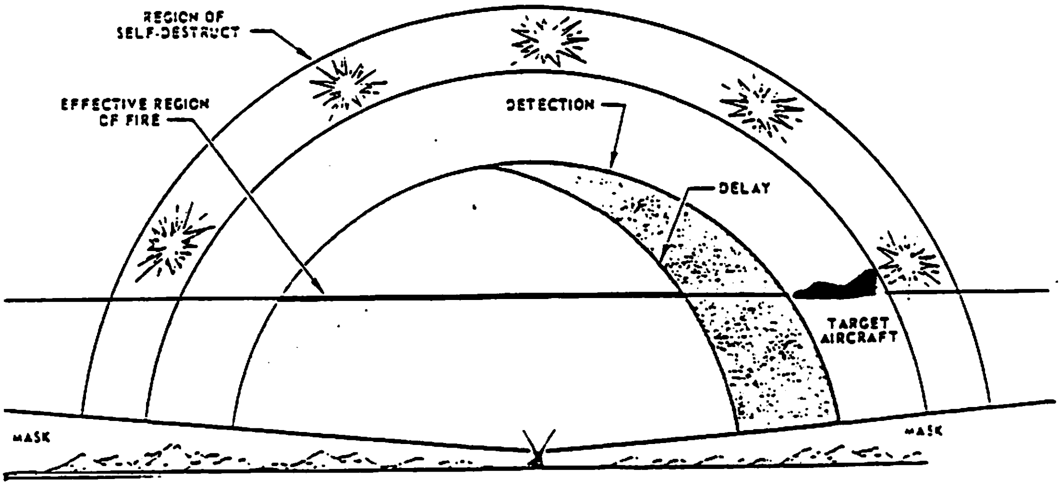
a. **Effective Fire Region.** Figure 6-2A-1 illustrates the effective region of fire for optically controlled guns including automatic weapons. The range at which the target is detected depends on the meteorological visibility, target motion, target altitude, background contrast, and acquisition assistance provided (ie, early warning/acquisition radar). Under optimum conditions, the detection range for an on-mount optical mechanical computing sight or an electro-mechanical fire control director could be in excess of 15 nm. For an open sight, this range would be reduced to about 4 nm. After detecting, there is a period of delay in order to aim the weapon and track the target. Therefore, it is possible that the gun could be ready to fire with the target outside the effective region of fire. Under normal conditions, this probably would not be true. The self-destruct range for those projectiles so equipped is outside the effective range. The masking angle is determined by the surrounding terrain.

b. **Radar Controlled Weapons.** The situation for radar controlled weapons is illustrated in Figure 6-2A-2. Detection is approximately at the radar horizon, which is masked by the radar beam width as well as the terrain. Time delays are substantially longer for radar controlled weapons, thus reducing the region of fire for low flying targets. The self-destruct region is as discussed above with mechanical time fuzes employed on 85, 100 and 130 mm weapons.

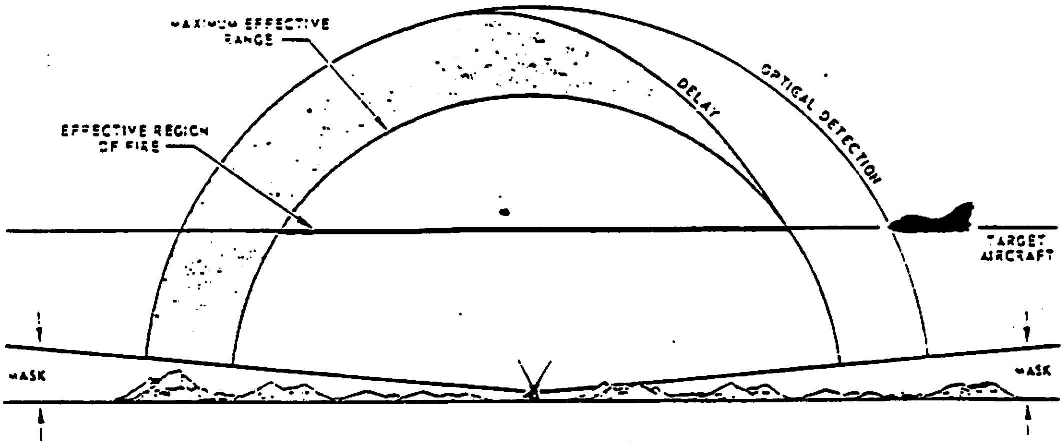
c. **General.** With either optical or radar directed fire, the majority of anti-aircraft fire can be expected when the aircraft is leaving the gun position, and a pilot may observe bursts in his vicinity even though he is not the target aircraft.

SECTOR INTERCEPT FIRE

11.(C) In the sector intercept method of fire, estimates of target altitude, range, speed and direction are obtained from the network of early warning radars and height finders (perhaps augmented by ground observer teams or acoustical detectors). This information is supplied to the target area commander, who then directs selected guns to fire into a designated area(s) at a given time. Fire is presumed to be random



Optically Controlled Weapons



Automatic Weapons

Figure 6-2A-1(S) - Aimed Fire - Automatic Weapons and Optically Controlled Guns

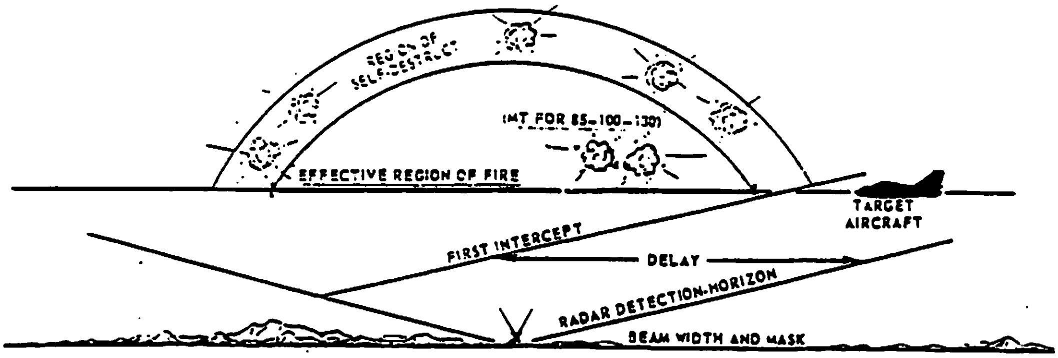


Figure 6-2A-2(S) - Aimed Fire - Radar Controlled Weapons throughout this sector. The commander could use some tracers, or possibly short time self-destruct fuzes, to observe distribution of fire and possibly change sector on later information as to aircraft profiles. Figure 6-2A-3 depicts this type of fire.

BARRAGE FIRE

12.(C) In barrage fire, estimates of target altitude, range, speed, and direction are again obtained from the network. At a given time, on the basis of estimates by the area commander, all

Aimed Fire	Barrage or Sector Fire
Attacker's Advantages:	**Attacker's Advantages:**
Effectiveness sharply dependent on barrage number of attacking aircraft.	Diversity of direction widens and thus reduces effectiveness.
Evasive tactics will degrade effectiveness.	May be expensive in defensive ammunition.
Jamming will reduce effectiveness of radar controlled guns.	Feinting tactics may reduce enemy ammunition supply.
Most fire dependent on good visibility. warning	Dependent on reasonably good net.
High dive angles should markedly reduce effectiveness.	
Requires high degree of training of gun crews.	
Attacker's Disadvantages:	**Attacker's Disadvantages:**
Diversity of direction will have little number of attacking	Effectiveness not dependent on aircraft effect..
Economical with defensive ammunition.	Evasive tactics may increase effectiveness.
Feinting relatively unimportant. effect.	Jamming will have no particular
May not be very dependent on warning visibility. net	Relatively independent of
	High dive angles may reduce effectiveness but not markedly.
	Requires less sophisticated training of gun crews.

Table 6-2A-3 (S) - Characteristics of Type of AAA Fire Control guns in a given sector about the ground target area are directed to fire at random approximately vertically in a cone with a relatively small sector angle. Fire continues until the last aircraft appears to have left the target area. Guns will fire at maximum sustained rate, although duration may be limited for some guns by heating problems. Figure 6-2A-4 depicts this type of fire.

COMBINATION FIRE

13.(C) It is possible that during sector intercept or barrage fire, some guns may be able to acquire targets and subject them to aimed fire. Thus, an aircraft may be subjected to sector or barrage fire during part of its attack profile and aimed fire during another. The characteristics of each type of fire are summarized in Table 6-2A-3.

FIRE CONTROL SYSTEMS

14.(U) The various fire control systems are descibed below:

a. **Open Sights.** Open sights that are used in some AW (12.7 mm or less) and LAA guns (30 mm) are equipped with a variety of rings and crosshairs, and lead computing is performed by the human operator. The operator relies on tracers to make aiming corrections. Against a 400 KTAS target the accuracy is of the order of 120 mils. These sights may have some usefulness against aircraft up to about 500 KTAS. The accuracy probably deteriorates rapidly with speeds above this value. The useful range of the weapon is limited by such accuracy and also by the requirement for good tracer visibility.

b. **On-Mount Optical Mechanical Computing Sights.** Computing sights using reflex optical components are mounted on the carriages of some AW, 23 mm, 27 mm and 57 mm guns. The gun commander can order changes set into the computing mechanism by observation of tracers. Intelligence information indicates that these sights are useful against targets with speeds up to 275 KTAS, and then suffer serious degradation. At 275 KTAS, the accuracy of these sights is on the order of 27 mils.

c. **Electro-mechanical Fire Control Directors.** Fire control directors are used to control some LAA guns (23 mm, 25 mm, 30 mm, 45 mm and 57 mm) and all MAA and HAA guns. The director computes azimuth, elevation, and fuze settings including parallax corrections) and transmits this information to the guns. The gun crew can follow the director by using handwheels to keep pointers at zero (semi-automatic) or, once pointers are zeroed, by switching to fully automatic. Inputs to the director can come from fire control radars on from an optical tracker/range finder. Four modes of operation are specified:

(1) **Radar Range Only.** Radar range is fed into the computer and the target is angularly tracked by an optical tracker/range finder. This is the preferred mode of operation.

(2) **Radar Mode.** All inputs are derived from fire control radar.

(3) **Optical for Constant Altitude Targets.** Range is set manually, and angle tracking is performed optically.

(4) **Optical for Target Resolution.** Range and angle tracking are obtained from the optical tracker/range finder using 32-power split image optics. The small angle of view of 32-power optics may produce acquisition and tracking problems.

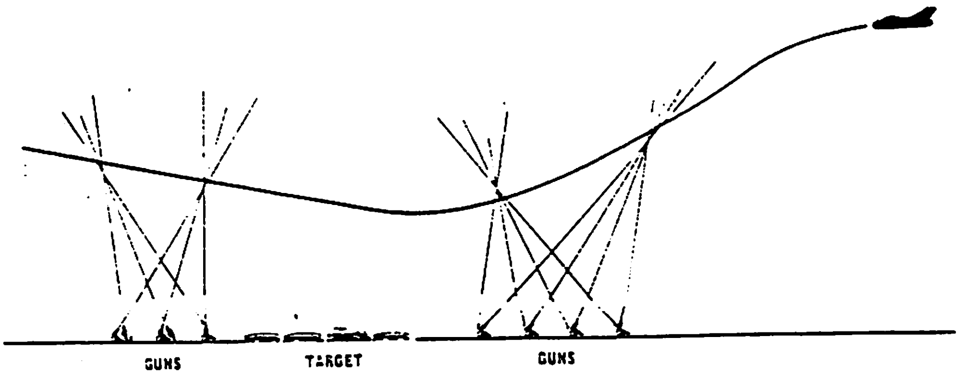


Figure 6-2A-3(S) - Sector Intercept Fire

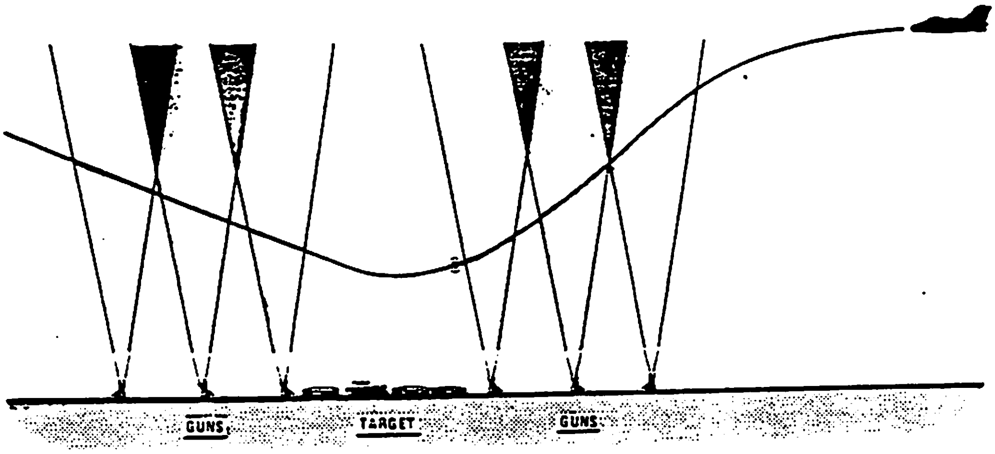


Figure 6-2A-4(S) - Barrage Fire

The accuracy of such directors is a complex function of range and aircraft speed, varying between approximately 1 and 15 mils against non-manoeuvring targets. Against manoeuvring targets the accuracy may be degraded by factors of 2 to 10. Radar may be employed to provide inputs to the fire control computers used to direct various gun systems.

LAND-BASED GUN SYSTEMS

15.(S) Soviet trained tactical forces continue to retain a number of AAA weapons in the inventory, although phasing out of older AAA is taking place with the concurrent introduction of the more recent SAM systems. One exception is the radar-directed, self-propelled ZSU-23-4. The improvement in low-altitude capability will compress the altitude at which ingress to targets can be made and, coupled with ECCM features, will provide a formidable barrier to attacking aircraft.

a. **The Future.** For the immediate future, the Soviet trained forces will continue to retain some conventional AA artillery guns suitable for employment as low-level air defence in the field armies. Large calibre weapons (95 mm, 100 mm and 130 mm) will probably remain in a reserve status.

b. **Retrofits.** The development of medium and heavy calibre weapons has been discontinued with their mission taken over by SAM systems. Retrofitting of AA machine guns to tanks, which were removed in the 1950s, is in progress. This is evidenced by the fact that modified T-62 turrets mounting a 12.7 mm machine gun are employed. This trend is also carried forth on the 152 mm M1973 self-propelled gun and the M1974 artillery command and reconnaissance vehicle. Realization of the Free World anti-tank helicopter threat is probably responsible for this action, and the trend is expected to continue.

c. **General.** Table 6-2A-4 contains a compilation of selected characteristics, performance data, and operational capabilities of Soviet and Czechoslovakian designed and produced AA gun systems. The Table includes both those systems presently active and those systems considered to be either limited, standard, or obsolete.

Weapon System	Range (ft)			Rate of Cyclic (Rds/min/ Gun	Muzzle Velocity	Ammunition	
	Tactical	Maximum Vertical	Maximum Horizonta		(ft/sec	Type	Projectile Weight (lbs)
12.7 mm Quad AA HMG(Czech)	3280	18,375	22,970	540-600	2725-2795	AP-I API-T	1.6 1.5
ZPU-1 14.5 mm Machine Gun	4595	16,400	22,970	550-600	3280	API API-T IT HEI	2.2 2.3/2.0 2.0 2.0
ZPU-2 14.5 mm Machine Gun	4595	16,400	22,970	550-600	3280	API API-T IT HEI	2.2 2.3/2.0 2.0 2.0
ZPU-4 14.5 mm Machine Gun	4595	16,400	22,970	550-600	3280	API API-T IT HEI	2.2 2.3/2.0 2.0 2.0
ZU-23 23 mm AA Gun	8200	16,735 (API-T)	22,970	800-1000	3180 (new) 3050 (std)	API-T FRAG HELI-T	6.5 5.2
ZSU-23-4 23 mm Quad SP AA Gun	8200	16,735 (API-T)	22,970 (API-T)	850-1000	3180 (new) 2050 (std)	API-T FRAG HELI-T	6.5 5.2
H53/59 and 53/70 30 mm Twin AA Gun SP(Czech)	(53/59) 9845 (53/70) 11,480	20,870	31,825	420.450	3280	HEI-T API-T1	0.93
M1939 37 mm AA Gun	8200	19,685 (AP-T)	26,260 (AP-T)	160-180	2885	FRAG-T AP-T	1.6 1.7
S-60 57 mm AA Gun	13,125 w/on carriage FC 19,685 w/ SON-9-PUAZO 6-60 FC 21,330w/RPK-1AFC	28,870 (APC-T)	39,370 (APC-T)	105-120	3280 (new) 3150 (std)	APC-T FRAG-T UOR-281 UOR-281U	6.2 6.4 6.4
ZSU-57-2 57 mm Twin SP AA Gun	13,125	28,870 (APC-T)	39,370 (APC-T)	105-120	3280 (new) 3150 (std)	APC-T FRAG-T UOR-281 UOR-281U	6.2 6.4 6.4
M1939 85 mm AA Gun	33,465 w/off-carriage FC 13,125 w/on-carriage FC	33,465	50,855	15-20	2885 (FRAG/AP-T) 3380 (HVAP-T)	FRAG AP-T HVAP-T	20.3 20.7 11.0
M1944 85 mm AA Gun	38,060 w/off-carriage FC 13,125 w/on carriage FC	38,060	59,060	12-15	2885 (FRAG/AP-T)	M1939 gun plus U0-366 & Czech made FRAG & AP-T	0.9 approx
KS-19 M2 100 mm AA Gun	41,340 w/off-carriage FC 13,125 w/on-carriage FC	47,575	68,900	15	2950	FRAG APC-T	34.4 35.5
KS-30 130 mm AA Gun	45,015	72,180	96,000	10-12	3100	HE AP-T	73.9

Table 6-2A-4 (S) - Anti-Aircraft Gun Characteristics

INTENTIONALLY BLANK

CHAPTER 3 - TARGET AREA TACTICS

INTRODUCTION

1.(R) Target area tactics will be driven by the type and number of target defences, weapons carried, in-flight conditions, formation size and en-route tactics. Within constraints of the overall mission objectives, it would be unusual to find a greater priority than to keep attrition to an absolute minimum. To this end, missions that have been pre-planned and co-ordinated should be able to achieve surprise attacks whilst at the same time saturating defences. Run-in and off-target tracks must be co-ordinated to eliminate the risk of mid-air collisions. The constraints detailed by the Tornado Aircraft Self Damage Manual (ASC/SDM/5) for singleton and formation attacks should be adhered to and allowed for in squadron SOPs. Although initially crews will employ mutual support, self defence and EW tactics within the target area, ultimately weapon aiming must become the over-riding consideration.

2.(R) This Chapter considers tactics to be employed within a 20 nm radius of the target. Target Area Planning considerations are covered in Section 5 Chapter 5.

TARGET DEFENCES.

3.(S) Although close formation attacks may provide the maximum weapons effect, it is not usually tactically desirable to fly two aircraft close together in a hostile environment. A formation presents a larger target than normal and if one aircraft is hit the other may be damaged by debris. In addition, AAA radars tend to lag and thus there is a risk of a wingman being hit by rounds aimed at the leader. There is no ideal attack formation and every target and defence system must be examined and considered individually. The formation selected for the final run-in may not be the same as used en-route so that a formation change may be needed to ensure the maximum weapon effort is achieved against the target. It is usually best to channel the aircraft gradually into the final attack formation either just before or during the turn onto the LOA. Depending upon the position of known threat systems in the target area, the following tactics may be used on conjunction with the ECM suite when on LOA:

a. **Against SA-8.** The possibility of SA-8 defended targets exists and they would pose a significant threat to Tornado, especially for JP 233 attacks where aircraft may need to fly straight and level for more than half a minute. The most effective tactic is described in Para 5c of Section 6 Chapter 2.

b. **Against SA-3.** Direct overflight rather than a tangential pass of an SA-3 site can reduce the size of the SAM engagement envelope. This tactic is amplified in CS (RAF) Memo No 443 - An Assessment of Airfield Defences in East Germany - June 1983 (see also Para 16).

c. **Against ZSU-23-4.** Although Skyshadow can defeat the ZSU GUNDISH radar ranging, direct overflight of the AAA site would make the aircraft vulnerable to optically laid barrage fire.

OCA TACTICS

4.(C) The aim on an OCA campaign is to reduce the enemy's ability to carry out OAS operations in support of their ground forces or OCA/AI operations against allied installations including RAF airfields. Generally, airfields tend to be defended by older generation SAMs such as SA-3 and may be defended by AAA and AW. Other SAM systems may well be encountered. The SA-3 site would only be a threat to aircraft attacking the airfield if aircraft routed through, or attacked targets within, the low level coverage of the site. This threat could be countered by Skyshadow or by a suppression attack carried out on the SA-3 site prior to the main airfield attack. However, with the limited DS weapons available, it may be better to counter the threat from SA-3 by ECM and careful routeing rather than by expending weapons on an SA-3 site. Aircraft that directly overfly a SA-3 site are assessed as being less vulnerable than those which pass close to the site. Whatever defences are encountered within the target area, the basic tactics of low and fast (the former being the most important) combined with active ECM has proved most effective against very representative threat systems both on trials and exercises.

5.(C). A mixture of freefall and retarded deliveries co-ordinated within a formation should enable TOTs to be concentrated sufficiently to gain most from surprise and saturation of enemy defences. For instance, Low Loft, Mini-Loft and Laydown attacks using markedly different LOAs could be combined against either common or separate DMPIs, such as HAS sites, fuel dumps, taxiways, runways or SAM sites. Attacks against HAS sites should be planned to produce maximum disruption to a maximum number of shelters including if possible the COC, with collateral damage aimed at the access taxiway to the HAS complex. Crews might find themselves undertaking attacks with other weapons such as proximity fuzed 1,000 lb bombs or guns. Use of these weapons should not change the basic tactics discussed earlier in this paragraph. Information on ASD risk for these mixed deliveries is published in the ASD Manual.

AI TACTICS

6.(C) AI tasking will involve attacks against fixed and mobile targets.

7.(C) **Fixed Targets.** Tornado is well suited to attacks against fixed AI targets such as permanent bridging, railway yards, headquarters and depots. Successful attacks should be possible in both visual and non-visual conditions. Tactics will, in general, be the same as those used in airfield attacks as detailed above. LGBs could be used against bridges and specific tactics and procedures for the delivery of LGBs are at described in Section 9.

8.(C) **Mobile Targets.** Mobile targets should only be attacked in visual conditions. Attacks against static or mobile armour targets in non-visual conditions are unlikely to be successful. Trial RIBSTON examined this aspect of Tornado operations and produced the following findings.

a. Using radar from low level, Tornado was found to have no capability to acquire stationary or moving armoured targets outside 3.7 nm.

b. The GMR can be used to mark and track individual targets from 3 nm to release provided the target location is known in advance. Because of the time taken to achieve a successful lock-on (5 seconds), the 'Lock-on' mode of attack is unsuitable for low level overland attacks, especially against armour.

c. Auto-TF attacks are unlikely to succeed due to Tornado's inability to react to AP steering updates close to the target. The TF turn rate of 1.9°/sec is a major drawback to the completion of a successful weapon delivery. Attacks against mobile bridging equipment are feasible in non-visual conditions provided the location is known when planning but, operationally, may not be profitable because radar camouflage techniques would be easy to implement.

9.(C) **Bridging/Choke Point Tactics - Visual Conditions.** The following tactics are recommended for use by a four-aircraft formation dropping retard bombs against bridging and associated choke points in visual conditions. When the choke point is associated with a bridging operation, a visual reconnaissance of the area immediately before the attack would clearly be worthwhile. Confirmation of target deployment can help to eliminate confusion and ensure the most effective use of weapons carried. Recce Attack Interface (RAI) techniques might be possible for last minute updates subject to the levels of COMJAM encountered, but to be successful RAI should be practised in peacetime.

a. If the bridging unit is short, only one element at a time will be able to attack the target. A shallow dive attack is recommended; the second element should attack after approximately 40 seconds and from a different direction.

b. If the bridging unit is long enough, both elements may be able to attack simultaneously; consideration should be given to splitting the aimpoints to put two aircraft against the choke points and two against the bridging unit.

c. An alternative way of conducting this type of operation against a bridging point would be to employ a mixed mission load; 1,000 lb retard bombs for the bridging attack and BL 755 cluster bombs for attacks on armour.

FAC TACTICS

10.(C) Whilst it would be unusual for the Tornado to be tasked with FAC, the Gulf crisis showed that the Tornado force could be required to fly diverse types of missions. Therefore, Annex A highlights the main elements of CAS, as developed in the Central Region, and introduces some US techniques the Tornado force may be called upon to use in an OOA scenario.

BAI TACTICS

11.(C) The basic difference between CAS and BAI lies in the proximity of the target to friendly forces, and the control arrangements for its execution. Tornado should only be tasked with BAI in an emergency situation when a breakthrough cannot be contained. Lucrative targets should then become available at pre-determined choke points/kill zones. In these circumstances it could be worthwhile employing Tornados armed with BL 755 in visual conditions. The standard NATO technique of "Rear Brief" possibly followed by "update by FAC" is compatible with Tornado operations. This minimises RT traffic and may achieve a better first-run attack result since more time is available for pilots to plan and control their attack. Experience has shown that hand held maps should not be discarded entirely. It should also be noted that FAC techniques must be practised to produce the required level of success.

12.(C) BAI missions tasked short of the FSCL require co-ordination with land forces during the planning stage and may require co-ordination during execution. This will require an RT check from the mission leader with ASOC or the nominated controlling agency en-route to the target. BAI missions tasked beyond the FSCL, once requested and co-ordinated by the land commander, can be executed entirely under air force direction. However, some form of communication between the ASOC or other controlling agency and the mission is always desirable in case a higher priority task arises. In emergency, BAI tasks may be diverted directly onto urgent CAS tasks. Employment of aircraft against BAI targets without precise locations may be executed in the form of attack-attack interface, armed reconnaissance and, if sufficient recce resources are available, as recce-attack interface.

13.(R) **Recce-Attack Interface (RAI) and Attack-Attack Interface (AAI).** RAI is a tactical procedure to enhance the success of attack forces, primarily against mobile targets in a given area. It normally calls for a reconnaissance aircraft to be tasked to the area in order to update and validate the position and nature of enemy forces, and then to pass this information to the attack force using the in-flight report. Normally there will be insufficient recce resources to allow concentrated RAI. The logical substitute is to provide AAI where a flying unit uses its own aircraft to provide the 'eyes' for the remaining attack package. This has the advantage of allowing thorough face-to-face planning to take place, overcomes authentication problems and allows abbreviated/coded airborne briefings to be made.

OFF-TARGET TACTICS

14.(C) Off-target, crews should normally fly their Tornados low and fast without turning. This tactic is easy to fly following laydown and shallow dive attacks but is more difficult following strafe attacks when a turn or climb has to be made to avoid debris - turning is the preferred option. The return to OLF from all loft attacks requires practice and, to allow for formation attacks in all weathers, must be simple - thus the procedures detailed in Annexes B and C are recommended. A hard turn onto the escape route can be made when crews assess they are clear of the target defences - typically this could be between 20 or 30 seconds after weapon release for laydown attacks. To aid in the post-attack rejoin, elements should route through a common TRP. Crews should endeavour to rejoin at least as mutually supporting pairs, as quickly as possible.

15.(R) **Battle Damage.** An aircraft which has sustained battle damage should continue as a singleton. An attempt should be made to reach friendly territory and, in spite of what is recommended above, an immediate turn for 'home' off-target may be the best option, especially if the aircraft has a fuel leak.

MEDIUM LEVEL TACTICS

16.(S) The Gulf conflict saw rapid developments in the tactics used by the Tornado force. It was found that the same principles of low level tactics should apply with the subtle difference of a third dimension available for manoeuvring. Points to note are as follows:

a. Formations must make every effort to vary routeing on subsequent missions.

b. Formations must try to vary their tactics - this includes formation positions, composition, spacing and attack profiles.

c. Crews must ensure that their flightpath is unpredictable by weaving and changing altitude. ATP 44 recommends 'random changes of the aircraft flightpath, with heading changes of 10°-30° and altitude displacements of 500-1,000 ft. As a rule of thumb, a change should be made at intervals at least equal to the $^1/_2$ of flight altitude in thousands of feet expressed in seconds (eg, an aircraft at 14,000 ft should change flightpath every 7 seconds, an aircraft at 10,000 ft every 5 seconds).

d. Cross-cover should be provided within formations to observe SAM launches and trajectories. Verbal support can then be provided to the targeted aircraft. This cross-cover is especially important during weapons delivery when the crew will tend to be more 'head-in'.

e. Finally, reduce the time spent in threat areas by exiting at the highest practicable speed.

RE-ATTACKS

17.(R) Experience gained (at a cost) during the Falklands War re-emphasised the need to complete a successful first-run attack against all targets since most associated defence systems can be expected to perform better once they have been alerted. In Tornado, re-attacks are rarely practicable. Operating primarily in non-visual conditions would mean that unplanned re-attacks would be generally tied to the original LOA thus requiring a large race-track to be flown for which there is unlikely to be sufficient fuel. In visual condition, a re-attack might be feasible against BAI type targets when the pilot, being more familiar than on the first run with the target area and relative disposition of targets, could make a 'direct' attack thus overcoming any target acquisition problems previously experienced. Because BAI targets may be nearer than pre-planned OCA/AI targets, crews should have sufficient fuel for a possible re-attack. Any decision to reattack must be weighed against the likelihood of higher attrition rates. Whether or not to re-attack must be briefed on the ground prior to each mission and any re-attack plan should, when possible, allow for an adequate time lapse and use a different LOA from the first pass. Overall, re-attacks are not recommended.

REMEMBER THE LESSONS OF CONFLICT - PREDICTABILITY KILLS!

INTENTIONALLY BLANK

CLOSE AIR SUPPORT

CAS - THE CR PERSPECTIVE

1.(C) CAS is air action against hostile targets which are in close proximity to friendly forces and which requires detailed integration of each air mission with the fire and movement of those forces. Co-ordination and control of air missions at the FLOT is performed by a Tactical Air Control Party (TACP) of whom the FAC is the forward element at the battle-front. During close support operations, camouflaged and tactically deployed targets can be very difficult to acquire and the use of a Forward Air Controller (FAC) can considerably enhance the chances of target acquisition. The use of Laser Target Marking (LTM) offers by far the best aid to target acquisition and, thereby, a successful attack. If the LTM and LST are operating properly, there remains very little else that the FAC needs to do to improve matters. Details of FAC procedures are contained in ATP 27B and AAFCE Manual 80-2. In general, the current procedure is to route outbound via a rear briefing agency (ASOC, ALO, surface vessel or airborne relay) to receive sufficient information to carry out an attack should communications with the FAC prove unworkable. After receipt of the rear brief, the FAC is contacted for a final update or a complete re-brief of the attack should circumstances dictate. The rear brief/forward brief concept is designed to reduce time spent in the target area, overcome possible communications problems with the FAC, and with LTM available allow a 'no-comms' attack to be carried out. Although the BL 755 is the primary CAS weapon, LGBs now have a place as a battlefield weapon against FAC marked targets such as bridges. The following points should be considered:

a. **TOTs.** TOTs for FAC missions will be given as either a specific time, as an ASAP task or as a No Later Than (NLT) time. The TOT normally applies to the time over the Control Point (CP); however, for missions tasked with LTM the TOT is the time of LTM switch-on. If no CP is given, then TOT is at the IP. If a TOT cannot be met ±1 minute whilst airborne, then a request for an alternate TOT must be made through the ASOC and then to the FAC as soon as possible. Where no RT contact is established with the FAC, laser marking will commence at TOT minus 1 minute and last until TOT plus 1 minute. If visual contact is made with the aircraft, then target marking will start at that time.

b. **Rear Brief.** Contact with the rear briefing agency should be established early enough to enable target changes to be assimilated whilst en-route to the CP without the need to hold. Data insertion should be carried out first by element leads whilst wingmen look-out and, once the leader is happy, the roles should be reversed. Authentication of all agencies is mandatory.

c. **FAC Brief.** Authentication of FACs is mandatory. FACs are not required to pass information other than the IP, target location (in UTM) with heading and distance from the IP, a target description, and information on the position of friendly forces. Attack clearance will be given once the mandatory information has ~~been~~ read-back to the FAC. If additional information is required it must be requested following the acknowledgement of the mandatory information.

d. **RT.** RT transmissions should be restricted to bursts of less than 2 sec to reduce the risks of enemy RT jamming.

e. **Abort Codes.** Abort codes must be passed to the FAC when leaving the IP. Abort codes should be pre-briefed within sections so that wingmen, if they hear nothing else, can recognise an abort call should it occur.

f. **CP Holding Procedures.** Rear briefing should reduce the need to hold at the CP. However, if a hold is required, due to last minute changes to the brief for example, then a pre-briefed holding procedure should be employed. The formation chosen should allow the leader freedom of manoeuvre while still retaining a measure of cross-cover lookout and mutual support. Work sharing should be employed within cockpits as per the rear brief, so that whilst the navigator copies and inserts data, the pilot does the lookout. The best way to hold is in a race-track of approximately one minute legs flown at transit speed. The race-track can be oriented on the heading to the IP, or if holding at the IP, oriented with the attack heading. The latter has the advantage of being able to leave the IP on heading but may not make best use of terrain and only allows one 'look' at the IP per orbit. These are not significant drawbacks if the weather is good or there are no navigational kit problems. The other method is to hold in a figure of eight pattern centred on the CP/IP. The figure of eight can be oriented to make best use of terrain, and the IP is passed twice per pattern which reduces the chances of not seeing it again in poor visibility. Turns for either type of hold should be away from the wingman to reduce deconfliction and RT clutter. Aircraft should fly as low as practicable, although the leader may have to climb to maintain RT contact with the FAC. RT problems make clear, concise read-back of information by the leader to the FAC doubly important as the leader's RT may be the only radio transmissions that the wingmen can hear.

g. **Formation Tactics.** Although the basic attack formation will have been pre-briefed, the decision as to which side to place the wingman will often need to be left until after the FAC brief. A good starting point is a swept defensive formation with the wingman arranging himself on the outside of the attack for a tip-in. This has the advantage that the leader is the first aircraft to be seen by the FAC, thus avoiding confusion. For straight-in attacks, the wingman will need to choose the best side with regard to acquisition, terrain, sun, weather, etc. In all cases, the wingman must have plotted the target position on his 1:50,000 maps; the target bars should give adequate visual acquisition cues, but bear in mind that there could be height channel error.

h. **Egress.** Aircraft should egress the target area immediately after the first pass whether successful or not. The first priority is to put terrain between the aircraft and the target attacked.

i. **Re-attacks.** Re-attack philosophy is covered in Section 6, Chapter 3, paragraph 17 because re-attacks require careful pre-planning. Ad-hoc re-attacks will usually result in unacceptable rates of attrition. However, on the day, it may become imperative that certain targets are destroyed by a specified time using limited resources; in this case re-attacks may well be necessary. The secret to a successful re-attack is to have thought about it beforehand and to incorporate the advice given in the planning section.

CAS - THE US PERSPECTIVE

THREAT SCENARIO

2.(C) The techniques used to deliver ordnance can be varied to suit the terrain, type of target and to increase delivery accuracy and provide a greater degree of acquisition probability. Ultimately the techniques and delivery method employed will be dictated by the threat in a particular area. The threat can be divided into 2 categories.

a. **High Threat.** - an area where the threat consists of radar guided SAMs, radar laid AAA and the later IR SAMs, possibly with an air threat on the periphery of the ground battle.

b. **Low/Medium Threat.** - an area where the threat consists of small arms, 12.7 mm and 14.5 mm AAG, optically laid AAAs and hand held IR SAMs.

3.(C) In the normal area of operations CAS aircraft are is likely to be employed exclusively in a high threat scenario. However, for OOA operations low/medium threat tactics may be an option. The following paragraphs outline some US techniques for both high and low/medium threat CAS with some relevant terminology and briefing formats.

HIGH THREAT

4.(R) A high threat scenario would normally require a very low level ingress and a high speed first pass attack, using all available EW assets, to achieve success. The attack could be carried out by as few as 2 aircraft, or many pairs of aircraft co-ordinated by the leader of the first element.

5.(R) **Communications.** Two way communication, between the FAC and the fighter element and between aircraft within a formation, is vital to the success of a CAS mission. The use of Have Quick can simplify communications and contribute to the success of the mission in a COMJAM environment. Alternatively, use of minimum communications delivered in short bursts, in a standard briefing format may be successful. A pre-briefed 'chop' frequency, or system of frequency changes, must be carefully briefed by the leader of a formation to ensure that communications do not break down within his formation.

6.(C) **Use of VHF.** The Soviet trained enemy should make great use of VHF radio frequencies. In a battlefield area they are unlikely to jam completely all UHF channels. Use of VHF may be a suitable alternative should Have Quick not be available, as it is less likely to be swamped with jamming than UHF.

7.(R) **Inter-Aircraft Communications.** Communications between elements, or element leaders and wingmen can be minimised by thorough pre-flight briefing of attack options, formations and individual roles for each member of the formation. Pre-briefed attacks can be initiated by single syllable words on the radio or 2-way communications can be eschewed entirely by the use of visual signals.

8.(R) **Abort Code.** It is vital that an abort code is decided before an attack commences. This can be achieved using authentication tables, so that a single word or letter can abort the attack if necessary. Use of this method may be successful during comjamming and can avoid fratricide. The FAC is responsible for giving positive clearance to drop, but anyone can call an abort!

9.(R) **Attack Roles.** There are 5 roles in which an individual aircraft or element can be employed. They are as follows:

a. Suppresser

b. Shooter

c. Cover

d. Decoy

e. Recce

10.(R) **Suppressor.** An aircraft in the suppressor role would normally aim to hit the general target area, or a secondary, or lesser threat, so that the main package can enter into the target area unhindered to attack the primary (key target) selected by the ground commander. This may be a 'softening' blow in the target area or merely a way of causing moving vehicles to halt and so create a target whilst NBC precautions are being made. In any event it is designed to cause disarray to the ground troops.

11.(R) **Shooter.** The task of the shooter is to deliver ordnance onto the primary target as designated by the FAC/Ground Commander.

12.(R) **Cover.** The cover role is designed to provide a 'shooter' aircraft with some covering fire, or to put ordnance onto a secondary target, or previously unseen target during the egress phase of the attack (eg hitting an SA7/14 launch site).

13.(R) **Decoy.** The decoy role is not recommended over flat terrain in a high threat environment. In hilly terrain, however, a decoy may be used effectively to locate or distract a specific threat. The decoy aircraft would be used to seduce a SAM system into operation. This would normally be achieved by flying into the edge of a known threat envelope and unmasking from behind terrain for several seconds, not exceeding predicted acquisition and track times for the given system! This role is seldom used intentionally!

14.(R) **Recce.** On many occasions the shooter role turns into the recce role. This is usually caused by a bad target plot, a rapidly moving target array or target acquisition too late to employ ordnance. Briefings often use the double role "Recce/Shooter". However, the recce role may be used to search for enemy positions with a view to a follow-up attack.

15.(R) **Choice of Formation.** The choice of formation is dependent upon the target, the associated threats and the weapons to be used. Generally three options are available:

a. Wedge

b. Line Abreast

c. Trail

16.(C) **Wedge.** A position 30°-70° swept on the lead aircraft at 1-2 nm range. This formation is flexible and would be suitable for use with BL 755, Mk 20 Rockeye or cannon deliveries. It could also be used for combination attacks using BL755/Mk 20 or cannon for the lead aircraft, with the wingman using 1,000 lb bombs or Mk 82 series bombs. Basically, Wedge can be used for any combination of weapons that do not require attack intervals greater than 20 sec.

17.(R) **Line Abreast.** Line abreast is excellent when used against an area target. It is particularly useful when sufficient lateral spacing can be created to satisfy self damage criteria for 1,000 lb bombs.

18.(R) **Trail.** Trail formation would normally be briefed with an attack interval (ie "Trail 30.." meaning attack interval 30 sec). This formation is primarily for use with 1,000 lb bombs and Mk 82 GP bombs against a point target or small array (ie choke point).

19.(R) **Co-ordinated Pairs Attacks.** Generally in a 2-ship element the formation, role and weapons to be employed, plus a TOT are all that must be briefed prior to an attack. However, when 2 or more elements (who have not necessarily briefed together) perform an attack the brief should also include additional co-ordination/deconfliction information whether it be for self damage reasons or collision risk over a point target. The methods which can be used when co-ordinating 2 or more

2-ship elements can be summarised under 4 headings as follows:

a. Combined

b. Sectored

c. Simultaneous

d. Sequential

N.B. Combined and sectored define avenues of approach whereas simultaneous and sequential the attack intervals.

20.(R) **Combined.** The combined attack indicates that a combined avenue of approach to the target is used. It would normally be used with a sequential attack against a point target, but may be used with a simultaneous attack against a large enough target array which would permit lateral spacing and so avoid self damage

21.(R) **Sectored.** A sectored attack divides the approach to the target area and is shown in Figure 6-3A-1. The sector is allocated by the ground FAC or the first element leader. It may be described as grid references, using a certain grid line which one element has to stay one side of (eg 3/4 element stay east of 23 grid line). However, the preferred method is to use a natural topographical feature such as a ridge, river, railway or similar feature which is easy to see from the air. The ground FAC may also create a similar sector for a 2-ship element to create an airspace co-ordination area (ACA) to deconflict aircraft from friendly SEAD (artillery fire).

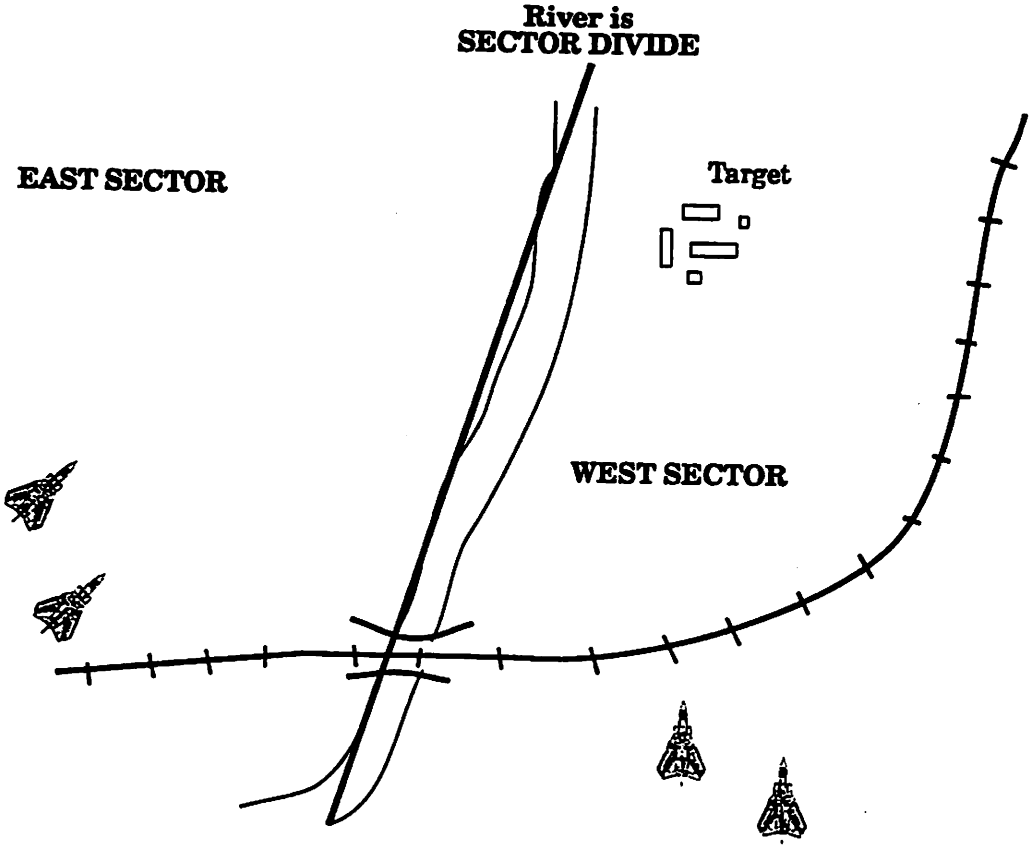


Figure 6-3A-1 (R) - Sectored Attack

22.(R) Simultaneous. A simultaneous attack can be made across a wide target array using 1,000 lb bombs or Mk 82 GP bombs provided adequate lateral separation can be maintained for all aircraft. However, a simultaneous attack can be made from a sectored approach when using forward firing ordnance.

23.(R) **Sequential.** The sequential attack usually has a nominated interval between elements or nominated TOT with reference to a common 'hack' time. The sequential attack is well suited to 1,000 lb bomb or MK82GP bomb attacks. The sequential attack can also be used in conjunction with the sectored approach when using short attack intervals from different attack headings.

24.(C) **The Aircraft to Aircraft Briefing.** The various options should be thoroughly briefed within a 2-ship or 4-ship formation and pre-agreed signals or codewords used in flight. However, the standard airborne brief when required should include the following:

a. **2-Ship Element.**

(1) Formation to be flown.

(2) Role for each aircraft.

(3) Weapons to be used (where a choice exists).

(4) A time hack + TOT if necessary for the lead aircraft.

Example. LION - Trail 30, Shooter/Shooter, Bombs, Ready Ready, Hack, 2 minutes).

b. **4-Ship or Co-Ordinated 2-Ships.**

(1) Avenue of approach with type of attack by elements.

(2) Formation to be flown.

(3) Role for each aircraft and weapons to be used.

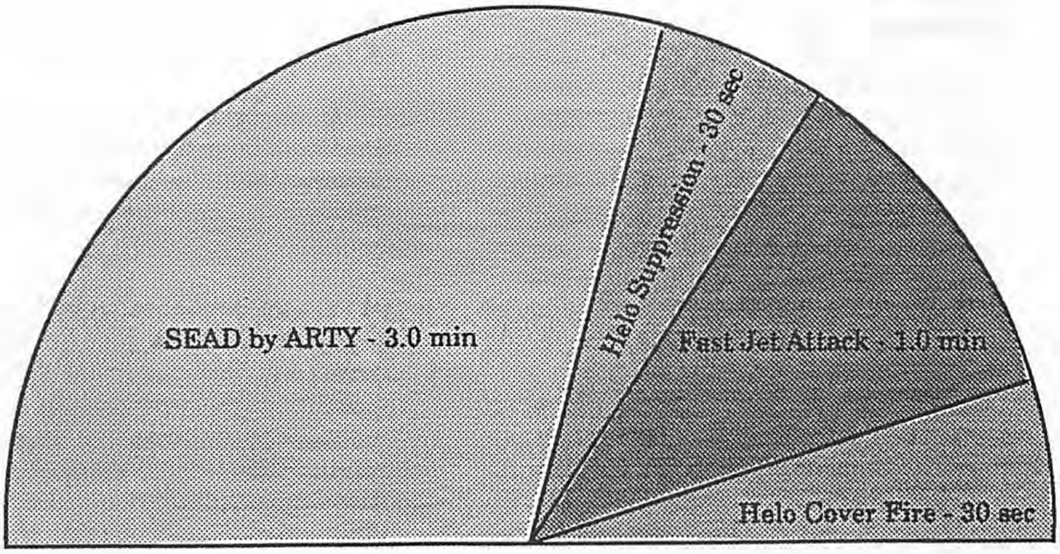
(4) Time hack and TOT.

Example. LION - Sectored/ Simultaneous, Wedge Suppresser/ Shooter, Guns/Bombs, Ready Ready, Hack-3 minutes).

Alternatively the formation leader may brief the avenue of approach, attack interval and TOT. The remainder would be completed within each element by use of visual signals or coded brief.

25.(R) **Summary - CAS Tactics.** These high threat CAS tactics are not exhaustive and are included merely as a guide, or framework upon which to build. However, the methods and briefing formats outlined are standard in phraseology and meaning to the USAF and US Army. In addition a technique involving SEAD, attack helicopters and CAS aircraft exists. It is Joint Air Attack Team (JAAT) tactics, and is described in principle in the following paragraph. JAAT briefs follow the same format and phraseology as CAS/BAI with one or two minor additions.

26.(R) **JAAT.** The aim of a JAAT attack is to destroy key targets against which area weapons such as artillery have a low P_k, or which helicopters cannot destroy with light firepower such as chainguns or rockets. Typical targets would be armoured command vehicles, or well dug-in APCs or armour causing the ground commander great difficulty in achieving his objective. A JAAT team normally consists of artillery SEAD units, attack helicopters and attack aircraft. The aim of the artillery and attack helicopters is to provide suppression and covering fire so that the attack aircraft can execute their attack on the primary target. When well co-ordinated, this system is excellent for attack aircraft which have to overfly the target in order to drop weapons. With stand-off weapons, the advantages or JAAT are much reduced. Co-ordination is provided by the Aviation Commander who is similar to an airborne FAC and normally the leader of the attack helicopter formation. His role is to co-ordinate the artillery with the fire support officer (FSO), control the attack team helicopters and, provide the target brief and weapons release clearances for the attack aircraft. He normally runs what is referred to as the JAAT clock, which is shown in Figure 6-3A-2.



Note. Helos terrain mask, move position prior to unmask during fast -jet attack

Figure 6-3A-2 - The JAAT Clock

LOW/MEDIUM THREAT

27.(C) In a low/medium threat scenario, the aim would be to ingress, release weapons and egress without exposing the aircraft to enemy threat systems. Threats include small arms 12.7 mm and 14.5 mm light AAG and optically laid AAA, SA7/14 and in some cases SA9 may be considered low threat if their position is known and the systems are few in number. A breakdown of threat zones is shown at Figure 6-3A-3.

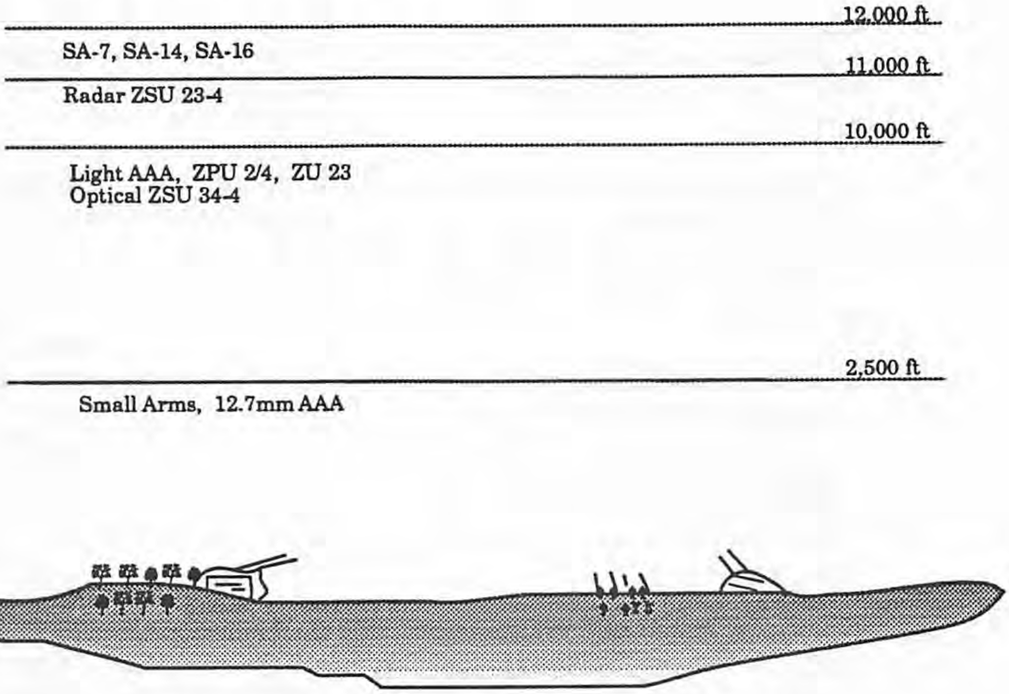


Figure 6-3A-3(C) Low/Medium Threat Zones

28.(R) **Delivery Techniques.** USUALLY ~~Invariably~~, delivery techniques will involve the use of 30°, 45° or 60° dive bombing or dive toss with 20° or 25° dive deliveries as a weather option. Parameters which keep the delivery aircraft out of the threat zone should, where possible, be employed. If the type of weapon or weather dictates that a threat zone must be penetrated to achieve success then exposure time should be kept to a minimum.

29.(R) **FAC to Aircraft Brief.** In a low threat scenario, it is quite conceivable that there will be little or no communications jamming. It is therefore much easier to receive a brief and more time can be taken to pass a detailed description of the target and ensure that all members of a formation have positively identified the target prior to the attack. In a low threat brief the FAC should:

a. Keep transmissions short to minimise enemy DF capability.

b. Not mention local names which may reveal the target location.

c. Provide the attack aircraft with a "unit" length which relates to a feature on the ground. (e.g. "Call the length of the lake one unit").

d. Provide the attack aircraft with a "direction" which is oriented along a feature on the ground. (eg "Call that railway line north/ south").

e. Brief the target from large to small features until the target is identified, using feedback questions to ascertain that the attack formation members are looking at the correct area as the brief progresses.

f. Pass any attack restrictions such as position of friendlies, attack direction limitations requirements or weapon-type restrictions.

g. Provide the final weapon release clearances.

30.(R) **Ingress and Egress.** Any form of tactical formation that can normally be employed at medium level should be used. Battle or Card are ideal where an air threat may exist.

31.(R) **Target Area Formations.** The ideal size for the target area formation is 2 aircraft, with the maximum size being 4 aircraft. Various methods of holding in the target area during the target brief can be employed. They are explained in the following paragraphs.

32.(R) **Holding Within Elements.** Fighting wing or trail are suitable formations for holding over the target area as they allow both formation members to lookout, and follow the FAC brief to find the target. In addition, the leader is free to manoeuvre as he wishes whilst the wingman can vary his flight path in 3-dimensions so as not to be predictable by following the leader. Finally a height-split can be used if necessary, particularly where doubt exists about the exact threats in the vicinity.

33.(R) **Holding Elements Within a Formation.** The same techniques apply as in paragraph 32. If weather prevents a height split between the elements then 4 aircraft in trail can be used. Alternatively, holding elements may be allocated sectors (in which they are free to manoeuvre) which are clearly defined by geographical features, eg rivers, railways, ridges etc. Combinations of opposite direction holds with height or sector splits will reduce the chances of the enemy achieving success with optically laid AAA or light AAGs.

34.(R) **Weapons Delivery.** The attack to be used against a particular target is always dictated by the threats surrounding it. Therefore in a low/medium threat small arms are always likely to be present, along with hand-held SAMs. In most events small arms will present the single largest threat, effectively creating a barrage

AL2(M5)

over the target area. Other known threats must then be considered. Once an appraisal has been made then a set of parameters which keep the aircraft out of the threat envelopes should be decided upon. Weather and cloud base may be a factor in the final decision; however, minimum exposure to the threat should be at the forefront of the decision making process. Finally, using an attack which has a high enough release altitude so that following aircraft are not restricted by self-damage separation criteria should be used where possible so that weapons concentration effects can be maximised. Ideal deliveries are likely to be dive toss, 20°, 30° and 45° with in some circumstances 60°. However, for all or any of these deliveries to be effective a considerable training and work-up period may be required.

35.(R) **Methods of Delivery.** It is possible to provide "cover" in a low/medium threat scenario in the same way as was described in Para 12. However, the "cover" aircraft would normally lurk at holding altitude providing lookout for the delivery aircraft. In the event of a secondary target being sighted, the "cover" aircraft can then engage the target. The shooter and cover roles work well within elements, being reversed during the follow-up attack when ordnance is still available. It is also possible to provide a simultaneous attack against a point target by use of a geographical sector, or a height split by use of differing release parameters. There is rarely a need for a simultaneous attack as low/medium threat targets using dive attacks seldom require such weapon concentrations.

INTENTIONALLY BLANK

ANNEX B TO
SECTION 6, CHAPTER 3 OF
TORNADO GR1 TACTICS MANUAL

TYPICAL MINI-LOFT PROFILE AND RECOMMENDED OPERATIONAL PROCEDURES

1.(R) The Mini-Loft profile is shown at Figure 6-3B-1. Times to overflight for various loft profiles, using the UK 1,000 lb FF bomb, are shown at Figures 6-3B-2 and 6-3B-3.

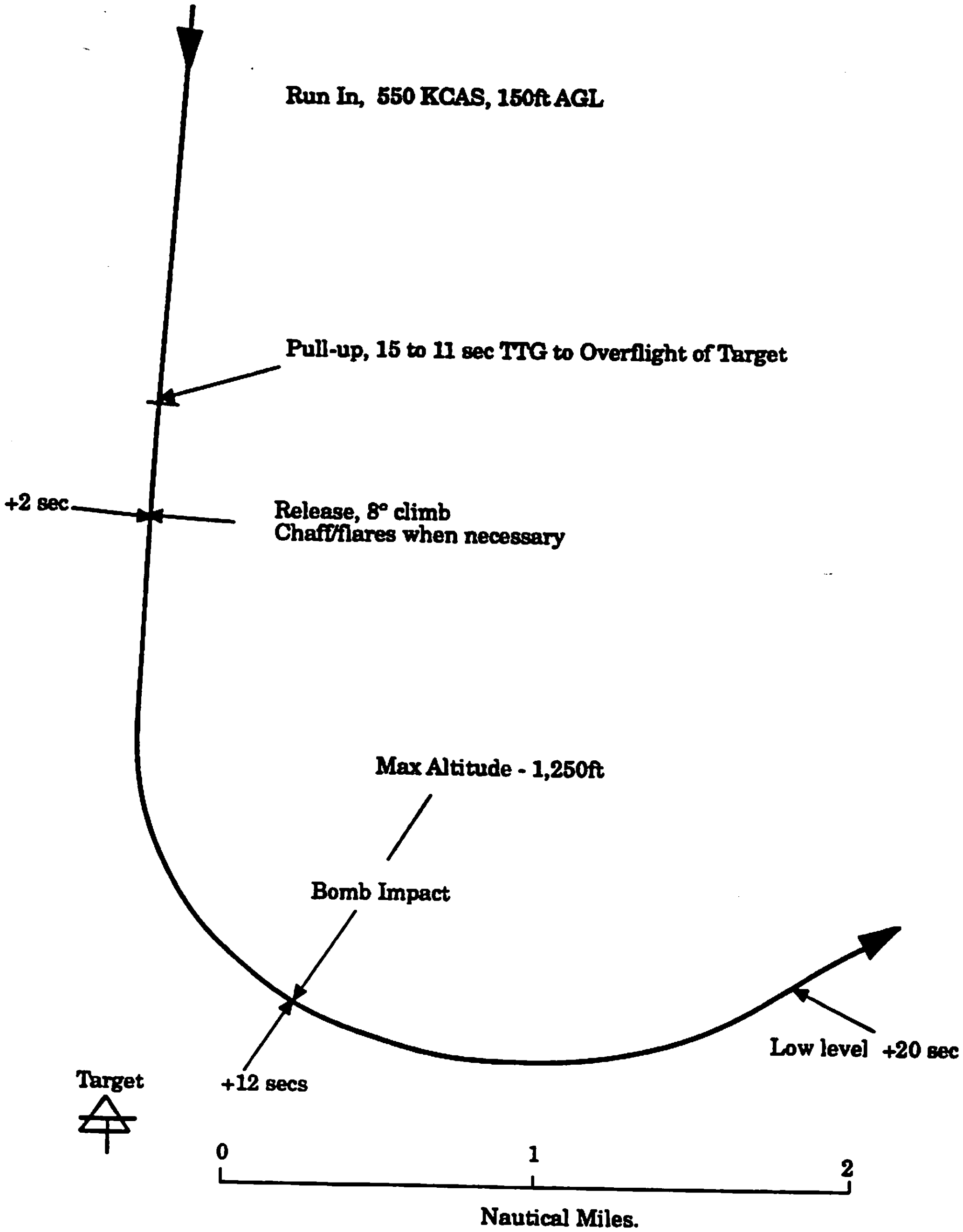


Figure 6-3B-1(R) - Plan View of Mini-Loft Profile

RECOMMENDED OPERATIONAL MINI-LOFT PROFILE AND PROCEDURES

Ser (a)	PHASE OF MINI-LOFT ATTACK (b)	CREW ACTIONS (c)	TYPICAL TIMES (in seconds with pull-up as zero) (d)
1	**Planning**	a. Crew chooses optimum LOA for visual acquisition at right angles to target surface. b. Crew select OAP close to but not beyond pull-up point.	
2	**Run-in Low Loft**	a. Pilot accelerates to attack speed of 550 KCAS and maintains ultra low level whilst flying the Bomb Fall Line (BFL) through the target bar. b. Navigator marks final OAP. c. If aim point positively identified, pilot tracks it with the BFL. d. When marking of OAP complete, navigator starts countdown to pre-determined Time to Go at pull-up (12 secs for an approximate 8° release). 012 should be entered in slide field for Auto Phase change.	minus 50 minus 20 minus 10 minus 5
3	**Attack**	a. Following Auto Phase Change, fly a 3'g' wings level pull-up. b. Bombs release automatically.	ZERO + 2

4.	**Recovery**	a. After release, pilot immediately rolls aircraft to 110° of bank using visual references.	+ 3
		b. Pilot commences a 4'g' descending turn and then monitors aircraft height and speed.	+ 6
		c. Bombs impact when aircraft at typical maximum altitude of about 1,250 ft.	+ 12
		d. At 90° ±30° off LOA, pilot rolls out of turn and then levels off at ultra low level.	+ 15 + 20

Notes:

The following points should be considered when flying Mini-Loft attacks:

1. **Mini-loft is a VMC only attack option.**
2. Chaff deployed in the target area may confuse follow-on aircraft.
3. Level flight should be maintained for at least 5 seconds before pull-up when using Baro/IN as a height sensor.
4. TTG at pull-up for Mini-Loft should be increased to allow for obstructions short of the target.
5. An alternative slant range height sensor should be used if the primary fails when height fixing.
6. Aircraft should recover away from each other to reduce risk of collision when flying parallel track loft attacks, unless target defences dictate otherwise.
7. Pressing in closer than 11 sec, or being slow is unsafe due to frag from own bombs.

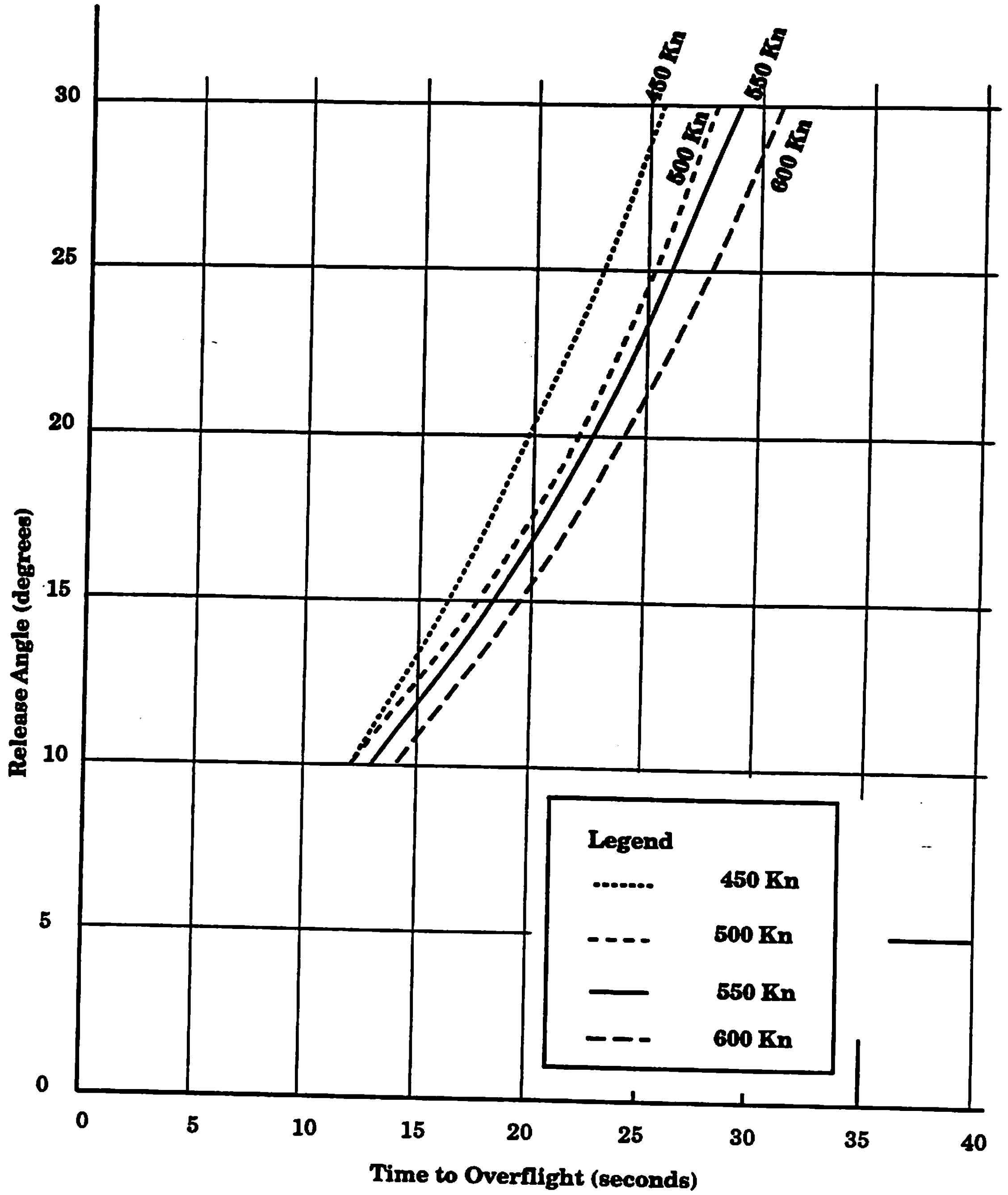


Figure 6-3B-2(C) - Time-to-overflight Values for UK 1,000 lb FF Releases, Entry Speeds 450-600 kn (Max, Dry Power)

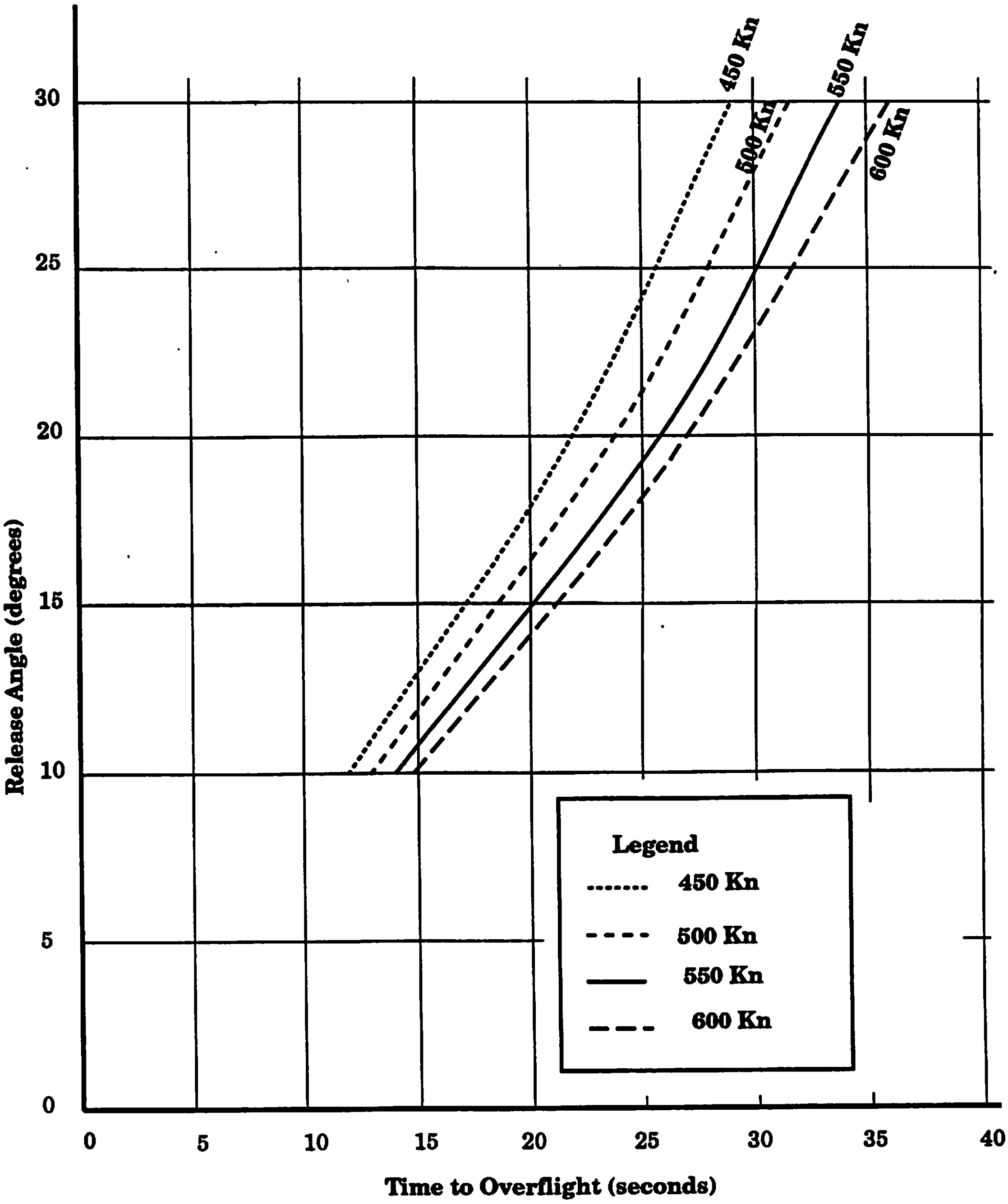


Figure 6-3B-3(C) - Time-to-overflight Values for UK 1,000 lb FF Releases, Entry Speeds 450-600 kn (with Reheat)

INTENTIONALLY BLANK

ANNEX C TO
SECTION 6, CHAPTER 3 OF
TORNADO GR1 TACTICS MANUAL

RECOMMENDED LOW LOFT TECHNIQUES

1.(R) **Use of Reheat.** The loft profile flown without reheat achieves a reduced apex height and exposure time, and hence aircraft vulnerability, without reducing the weapons effect. To compensate for the 50 kn that is normally lost in a dry power loft pull-up, 50 kn should be added to the entry speed to achieve the same release parameters. While the latter may require reheat, overall no more fuel should be used than normal and the aircraft should be less vulnerable because the IR emissions will be considerably less. Thus, when the tactical environment dictates and aircraft limits allow, low loft (LL) attacks could be flown without reheat.

2.(R) **Loft in Non-Visual Conditions.** The following ideal loft entry procedure is recommended because it gives the pilot his essential E-Scope reference right up to the PUP and allows an expeditious return to TF flight.

Pilot Actions	Time to PUP
a. Set HSI heading bug to escape heading	30 sec
b. Check HDD/HUD instruments	15 sec
c. Late arm - live	10 sec
d. ICO, simultaneously select maximum reheat (if required)	3 sec
e. Select Phase 2/Nav Press Hi Loft or Auto Phase Change (Auto Phase Change preferable)	0sec
f. Chaff/Flares as necessary	

It is essential to keep the TFR 'ON' throughout the loft manoeuvre to allow instant E-Scope reference for the pilot during the recovery, however, the TFR will trigger a number of nuisance warnings during the manoeuvre; these increase crew workload to a most unsatisfactory level and crews should be aware that other more important warnings may be masked.

3.(R) **Regaining TF.** To reduce aircraft exposure time, the escape heading should be reduced towards a minimum of 60° off LOA. The loft recovery as detailed in the Tornado GR1 Force SOPs should be flown with the TF checks being commenced as soon as the aircraft is established on escape heading. It will not always be possible to complete the TF checks before the minimum en-route altitude (MEA) is reached. Thus it is important to calculate a MEA specifically for the recovery sector having first selected an escape heading that would give the lowest possible MEA.

4.(R) **Parallel Track Loft Recoveries.** If two aircraft are briefed to execute line abreast loft attacks against the same target complex, the recovery manoeuvre (subject to target defences) should be planned outwards from each other to reduce the risk of collision and damage from the other aircraft's weapons (particularly after a ML attack) irrespective of the flight conditions. If same-way recoveries are required, a pair of aircraft should be separated by 1 nm laterally, 10 seconds in time and initially fly a slightly divergent escape heading.

5.(R) **Trial Reports.** AWC Trial Reports (previously CTTO) that are applicable to Tornado loft are listed in the Table overleaf.

Ser	Trial	Report	Type of Attack	Type of Bomb
1	Trial DAZE 4	CTTO/21/4/Air dated 13 Aug 82	Low Loft	28
2	Trial DAZE 6	CTTO/21/4/Air dated 15 Mar 83	Low Loft	1,000
3	Trial DAZE 7	CTTO/21/4/Air dated 27 Jun 84	Low Loft	1,000
4	Trial DAZE Final Report	TOEU/1550/3/Air dated 18 Apr 84	-	-
5	Trial MAYCOCK	CTTO/21/4/2/Air dated 20 Feb 84	Mini Loft	28
6	Trial TUMULT	TOEU/1550/5/Air dated 31 May 84	Mini Loft	1,000
7	Addendum One to Trial TUMULT	TOEU/1550/5/Air dated 19 Dec 84	Low Loft	28/1,000
8	Addendum Two to Trial TUMULT	TOEU/1550/5/Air dated 10 Jul 85	Tactical Aspects	28
9	Trial WRENTHAM	NR Letter Report dated Feb 85	Low Loft and Mini Loft	28/1,000

Section 7

Strike Phase

Chapter 1 General Considerations

SECTION 7 -TABLE OF CONTENTS

CHAPTER 1 - GENERAL CONSIDERATIONS

Introduction 1
Types of Mission 1
    Selective Use (Seluse) 1
    General Release 1
Characteristics of Nuclear Weapons 1
Weapon Loads 1

TORNADO STRIKE MISSIONS 1
Mission Planning 1
Software 1
In-Flight Procedures 2

CONCLUSION 2

INTENTIONALLY BLANK

CHAPTER 1 - GENERAL CONSIDERATIONS

1.(R) **Introduction.** Dual capable RAF aircraft may be required to release nuclear weapons in support of NATO or on a national basis. For NATO operations, overland strike aircraft are assigned to SACEUR and their missions are co-ordinated with other NATO nuclear assets.

2.(S) **Types of Mission.** Aircraft may be tasked for two types of strike mission:

a. **Selective Use (Seluse).** Seluse missions are tasked individually though a number of missions can take place at the same time. Some missions may be pre-designated whilst others may be tasked as reaction to events. Conventional missions tasked to suppress or decoy enemy defences may be co-ordinated to improve the probability of success of the strike mission. This procedure is called the Support of Nuclear Operations with Conventional Air Tasking (SNOWCAT).

b. **General Release.** General Release missions involve most strike capable weapons systems and are co-ordinated across NATO. The missions are pre-designated and are carefully planned to avoid mutual confliction. SNOWCAT is planned to support General Release but will be used for general defence suppression rather than in support of specific missions.

3.(R) **Characteristics of Nuclear Weapons.** Despite apparently vast power, nuclear weapons, especially tactical nuclear weapons, must be delivered with reasonable accuracy to achieve high damage levels. A fuller explanation of the types of burst and effects of nuclear weapons is given in the RAF Armament Support Unit Aircrew Manual for Nuclear Operations - Tornado.

4.(S) **Weapon Loads.** Tornado can carry the 600 lb and 950 lb HEMC weapons, both of which offer the choice of laydown and loft for groundburst or airburst. Two weapons can be carried, in which case two targets could be attacked, but if longer range is required one weapon can be replaced by a fuel tank. The release clearances for the carriage of other stores, such as AIM-9L, with the special weapon are given in the MOD (AFD) NWC/177.

TORNADO STRIKE MISSIONS

5.(C) **Mission Planning.** General release missions are pre-planned and crews should be familiar with every detail of the plan. Seluse missions will always be allowed sufficient planning time. Furthermore, because of the importance of Seluse missions, they should be planned by the crew designated to fly the mission. Crews tasked with Seluse missions should consider requesting SNOWCAT if it has not already been provided. All strike missions are flown as singletons and tactics to counter enemy air defences should be specially considered during mission planning as crews may need to penetrate heavily defended areas in visual conditions without the mutual support of a formation. However it is probable that, in the case of General Release, moderate to severe degradation of enemy defences will occur before and during the mission. The advice given in Section 5 of this Manual is applicable to the planning of all strike missions.

6.(S) **Software.** Tornado strike software inevitably lags the attack software; consequently, some of the facilities available using the attack software will not be available on strike missions.

7.(U) **In-Flight Procedures.** The tactics available to crews on strike missions are similar to those available on singleton attack sorties. The deconfliction criteria applicable to General Release missions should be strictly applied in order to provide for the safety of all strike aircraft. The low level return of strike aircraft on General Release missions is not advised due to the large number of nuclear weapon bursts on both sides of the FEBA. Notwithstanding the advice given in Section 6 of this Manual, the over-riding priority on all strike missions is to achieve weapon release on the designated target at the authorised time. The full (reheat) loft and escape profiles should be followed to allow the greatest separation between the delivery aircraft and the weapon burst.

CONCLUSION

8.(U) The penetration of the FLOT as a singleton to deliver a nuclear weapon will impose considerable stress on Tornado crews. Furthermore, the importance attached to strike missions in general, and to Seluse missions in particular, will add to the overall tension and could affect the success of the mission. This success will be enhanced by knowledge of the procedures, understanding of the software and by thorough flight planning and route study.

Section 8

Maritime

Chapter 1 Mission Planning

2 Airborne and Post Flight

3 Target Location and Identification

4 Sea Eagle Tactics

5 Paveway Tactics

6 Counter Amphibious Landing Operations

7 Maritime Reconnaissance

SECTION 8 - TABLE OF CONTENTS

Page Number
(within the Chapter)

CHAPTER 1 - MISSION PLANNING

Introduction 1
Data Sources 1
Pre-Tasking Actions 1
Tasking 1
Planning 1
Briefing 2
HAS Re-Tasking 2

ANNEXES

A: SEA EAGLE WEAPON EFFORT PLANNING

Factors Affecting the Weight of Effort A1
Hit Requirement per Target A1
Number of Sea Eagle Missiles Required for a 0.7 Probability of Disablement - Figure 8-1A-1 .... A2
Hits Required for 0.7 Probability of Disablement - Table 8-1A-1 .... A2
Losses to Hard Kill - Table 8-1A-2 .... A3
Losses to Hard Kill A3
Losses to Soft Kill A3
% of Hits after Soft Kill - Table 8-1A-3 .... A3
Methodology A4
HVU Attack A4
Attrition Attack A4

B: PAVEWAY WEAPON EFFORT PLANNING

Weapon/Target Matching Table -Paveway - Figure 8-1B-1 .... B1

C: DEFINITION OF DAMAGE CATEGORIES

D: MARITIME MISSION PLANNING AND BRIEFING SEQUENCE

CHAPTER 2 - AIRBORNE AND POST FLIGHT

Routeing in the UKADR 1
Routeing outside an ADR 1
IFF Procedures 1
Co-ordination with Ships Air Defences 1
  Ships With Organic Air Assets 1
Control of Airspace - Figure 8-2-1 2
  Ships With Non-Organic Air Assets 2
  Shipborne Defences Only 2
Co-ordination With AD Agencies 2
Maritime ACOs 2
Autonomous Fighter Operations 3
Autonomous Fighter Engagement Criteria - Figure 8-2-2 3
BRICKWALL Procedures 4
BDZ 4
Reporting 4

TASMO IN-FLIGHT REPORT (INFLTREP) 4
TASMO MISSION REPORT (MISREP) 4

CHAPTER 3 - TARGET LOCATION AND IDENTIFICATION

TARGET LOCATION 1
    Introduction 1

ATTACK SUPPORT 1
    Shadower 1
    Attack Support 1
        Tactical Direction (TACDI) 1
        VASTAC 1
    Visual Reconnaissance Probe 1
    Procedures 1
    Attack Support Resources 1
    Detached Probe 2

TORNADO SEARCH 2
    High-Level Search 2
    Unexpected Detection of Target 2
    Low-Level Search 3
        Search Pattern 3
    GMR - Optimum Height and Range for Initial Target Detection for a 100ft/50ft Mast High Target - Table 8-3-1 3
        Search Technique 3
        Formation Search 4
    Search Patterns - Figure 8-3-1 5
        Anaprop 6

PROBE TACTICS 6
    Time of Tension 6
    During Hostilities 6

DIVERSIONARY ATTACKS 7

CLASSIFICATION AND IDENTIFICATION OF TARGETS 7
    Introduction 7
    Identification Methods 7
        Visual Identification 7
        Stand Off Classification 7
    Classification/Confidence Rating 8
        Certain Identification (CERT) 8
        Probable Identification (PROB) 8
        Possible Identification Confidence High (POSS CONF HIGH) 8
        Possible Identification Confidence Low (POSS CONF LOW) 8
        Unknown (UNK) 9
    Contact Classification Matrix - Table 8-3-2 9
    Use of Classification/ Confidence Rating 9

ANNEXES

A: ATTACK SUPPORT

Initiation A1
Ordering the Mission A1
    Gates A1
Table 8-3A-1 (C) - Maximum Gate Spacing for Shadowing Platforms A1
    COVEC Values A1
SURPIC A1
VASTAC A1

APPENDICES

1. SURPIC

Purpose A1-1
Method A1-1
Reference Position (RP) (Para A) A1-1
Position Accuracy (Para B) A1-1
Data Time (Para C) A1-1
Disposition (Para D) A1-1
    Contact Serial Number/ Track Number A1-1
    Confidence Level A1-1
    Contact Designators A1-1
Target Mean Line of Advance (Para E) A1-1
Weather Report/ other information (Para F) A1-1
    F1 .... A1-2
    F2 .... A1-2
    F3 .... A1-2
    F4 .... A1-2
    F5 .... A1-2
    F6 .... A1-2
Repeat of RP (Para G) A1-2
Authentication A1-2
Broadcast Schedule A1-2
Abbreviated SURPIC or VASTAC A1-2
Deceptive Reports A1-2
Information Update A1-2
SURPIC Message Format - Table 8-3A1-1 .... A1-3
Example SURPIC Message - Table 8-3A1-2 .... A1-4
Example Abbreviated SURPIC Message - Table 8-3A1-3 .... A1-5
Selected Target Designators - Table8-3A1-4 .... A1-6
SURPIC Broadcast Schedule - Table 8-3A1-5 .... A1-7

2. ATTACK PROCEDURES

Introduction A2-1
Tasking A2-1
TRU Action A2-1
Attack Aircraft Action A2-1
IFF Procedures A2-1
    STRANGLE PARROT ONE A2-1
    STRANGLE PARROTS ALL A2-1
    BANDWAGON A2-1
Approach to the Target A2-1
STANDBY/MARK Checks A2-2
VASTAC Actions for Participating Units - Table 8-3A2-1 .... A2-2

3. FORM TURQUOISE

Format of FORM TURQUOISE - Table 8-3A3-1 .... A3-1
Example of Form TURQUOISE - Table 8-3A3-2 .... A3-2

4. BREVITY CODEWORDS (ACP 165E)

Codewords in alphabetical order A4-1/2

CHAPTER 4 - SEA EAGLE TACTICS

To be Issued

CHAPTER 5 - PAVEWAY TACTICS

To be Issued

CHAPTER 6 - COUNTER AMPHIBIOUS LANDING OPERATIONS

CIS AMPHIBIOUS CAPABILITY 1
    Administrative Lift 1
    Concept of Amphibious Combat Operations 1
        Embarkation 1
        Transit 1
        Preliminary Assault 2
        Main Assault 2

NATURE OF THE PROBLEM 3

SUGGESTIONS FOR OPERATIONAL PLANNING 4

ASSAULT CRAFT - VULNERABLE AREAS 5

CHAPTER 7 - MARITIME RECONNAISSANCE

INTRODUCTION 1

AVAILABLE SENSORS 1
    Visual 1
    Cameras 1
    Electronic 1

PEACETIME TACTICS 1

WARTIME TACTICS 2
    Probe Tactics 2
    Armed Reconnaissance Tactics 2
    Post-Attack Reconnaissance and Tactics 2

CHAPTER 1 - MISSION PLANNING

1.(S) **Introduction.** Ideally the centralized maritime tasking organization at MHQ Northwood should be able to task TASMO missions such that plenty of time is available for detailed mission planning. However, external factors conspire against this. During the free-play phase of TEAMWORK 88 the AHQ tasking staffs were faced with a fluid intelligence plot complicated by the effective use by the 'enemy' of deception groups, the Commander's tasking priorities changing in sympathy with the intelligence plot and with the sheer volume of effort needed to co-ordinate multi-asset attack, fighter, AAR, recce and attack support packages. As a consequence many tasks were passed to units in skeleton form, using secure voice, and followed-up with signals and ASMA messages detailing the rest of the tasking information. There is no reason to suppose that this should not be the case in the 'fog of war' although the careful husbanding of resources and the inclusion of US assets in the maritime war should reduce the MTW sortie rate below that experienced in the free-play phase of a major NATO exercise. There is still, therefore, a need for the MTW to be able to plan and mount sorties in a relatively short timescale. The adoption of AR5 procedures will further reduce the time available for task replanning. This Chapter covers the main data sources available for mission planning and the considerations involved in planning a maritime war mission.

2.(S) **Data Sources.** ATP 34, re-issued in Jun 88, is the TASMO 'bible'. It contains instructions on tasking, co-ordination, routing and IFF procedures. It also shows how Offensive TASMO fits in with the other aspects of TASMO, eg defensive, supporting and recce operations. It does not cover nuclear operations. Finally, ATP 34 covers all TASMO message formats including the IFREP. There is also a BALTAP supplement to ATP 34 which covers the extra procedures involved in operating in that region. The other main source documents are the 'Supplan Mikes'. Supplans 50001M, 20001M, and 35001M are respectively the airspace control plans for CINCUKAIR's, CINCNORTH's and COMAAFCE's areas of responsibility.

3.(S) **Pre-Tasking Actions.** There is a lot of information that crews must be aware of prior to planning a mission. Crews should be briefed on weather, intelligence and the in-force airspace control measures when they come on duty and then be regularly updated until stood down. In addition crews should regularly update their own IFF codes and crypto.

4.(S) **Tasking.** TASMO tasking is issued either as an AIRTASK message (ATM) or, when AAR support is involved, an AARCTM (Air-to-Air Refuelling Combined Task Message). Initial information may already have been passed to the Squadron by secure voice means. The lead crew must first extract the following information from the ATM : TASK, TIMESPEC, ROUTE, ALT, CPMA (Control Point and Description - ie the Gate), TARPOS, FYFORCE, FYPOS and ISR. The MHQ will specify the number of aircraft and the number and type of weapons to be used. Weapon effort planning guides for Sea Eagle and Paveway are at Annexes A and B respectively. Damage categories are covered in Annex C.

5.(S) **Planning.** The lead navigator should first plot the route and target, and check that the fuel is sufficient or that AAR has been tasked, that the TIMESPEC is achievable and then pass a take-off time to the Duty Exec. Meanwhile the lead pilot should organise the rest of the formation to compile the sortie brief and the mission briefing sheets.

6.(S) **Briefing**. If time permits a comprehensive sortie brief may be given, or the brief may just comprise a few words over telebrief following HAS re-tasking. In all cases the brief should be concise and concentrate only on the essentials, maximum use being made of SOPs. The important items are the latest intelligence plot and target update, the current airspace control measures, the loser plan and fallback plans in case of lack of attack support etc. At Annex D is a list of points for consideration during the planning and briefing cycle. Following the target update and out-brief crews will walk either to make a pre-planned take-off time or to be at r/s 30 at a given time to await an EXECUTE message.

7.(S) **HAS Re-Tasking.** The option exists to re-task crews in the HAS. This is particularly valuable during AR5 operations when time may not be available for a 'doff-plan-brief-don' cycle. A new lead crew may have planned the second mission whilst the first was in progress or the lead crew may remain unchanged. In either case the crews remaining in the HAS will receive new mission briefing sheets, waypoint and navigation sheets photo-copied maps plus new IFF codes and crypto. A thorough knowledge of SOPs, tactics and enemy capabilities is essential if this type of procedure is to succeed.

SEA EAGLE WEAPON EFFORT PLANNING

1.(S) **Factors Affecting the Weight of Effort.** The weight of effort needed for a Sea Eagle attack must allow for the following factors: hit requirement on the target, targeting accuracy, missile reliability, losses to hard kill and losses to soft kill. Attrition of the delivery aircraft by SANs is not considered as the missiles are released out of SAN coverage. If there is a fighter threat to a particular mission then either some form of fighter escort must be tasked or the attack package must be increased using the methods in the JMEM. The following calculations have been taken from various studies, as summarized in the CTTO Maritime Attack Study, and modified by information derived from recent BAe targeting studies.

2.(S) **Hit Requirement per Target.** Tonnage, volume, construction material and internal layout are the major factors in determining a ship's vulnerability. Tonnage and volume are closely related; in general the larger a ship the less vulnerable it is since the extra size allows duplication and redundancy which in smaller vessels would be impossible. As with most NATO ships, hydraulic, electrical and water systems are duplicated in Soviet ships; for example cables are routed along both port and starboard side. In very large ships some systems are triplicated (both sides and keel). It is difficult to duplicate large key installations, such as the operations room with its inherent computer hardware, but this is expected to be a feature of future Soviet designed ships. An alternative is to devolve operations away from the main operations centre, this situation exists in the latest Soviet ships. The experience of HMS Sheffield demonstrated that construction materials are very important to a ship's vulnerability. Most Soviet built vessels are made entirely of steel; aluminium alloys are rarely used. The internal layout of a ship will determine the optimum location for warhead detonation. In Soviet built ships, missile magazines and hangar decks are often surrounded by other compartments which afford a layer of protection. Of all these characteristics, the only available guide to weapon effort planning in the past has been by referring to a ship's displacement or tonnage This chapter goes on to describe the present method of weapon effort planning based on tonnage, but it should be borne in mind that DRA (Ae) Farnborough is carrying out an investigation into Ship Vulnerability. This study may provide a better appreciation of the number of missile hits required to disable a ship. A broad cross-section of CIS surface ships is being studied, and much use is being made of recent access to detailed studies of CIS vessels. When complete, these results will be used as the basis of a new computerized methology developed by HQ 18 Gp ORB, which should provide a more realistic assessment of weapon effort planning. However, until all these studies are complete, the best available model remains that based on a ship's tonnage. Figure 8-1A-1 shows the relationship between target tonnage and the number of Sea Eagle missiles required for a 0.7 probability of disablement.

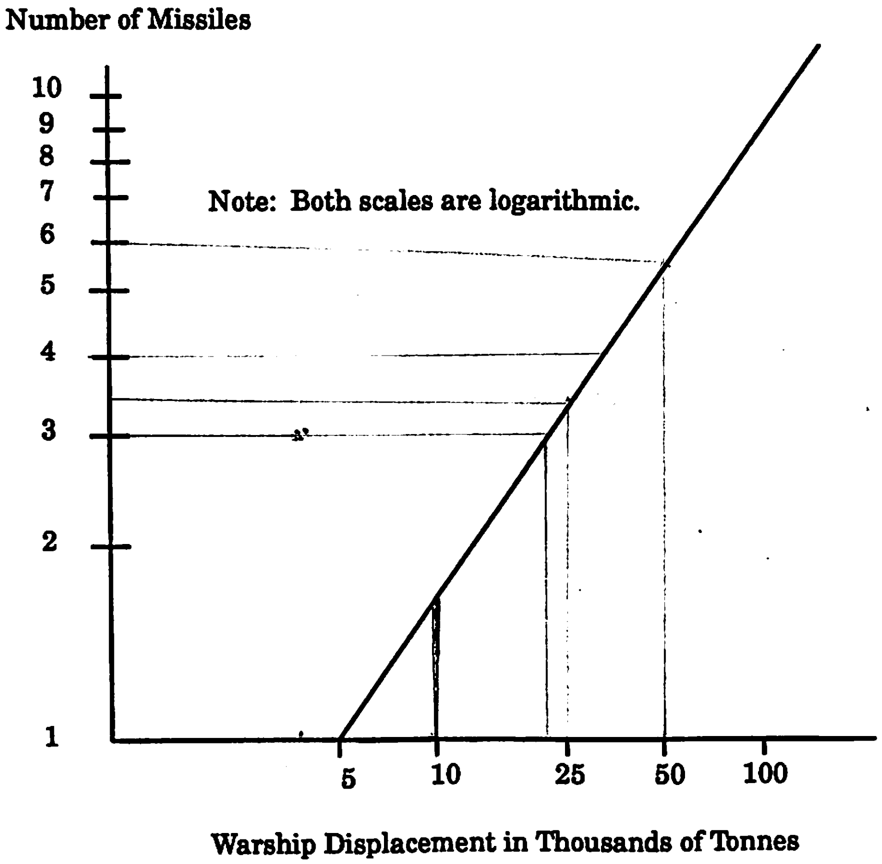


Figure 8-1A-1(S) - Number of Sea Eagle Missiles Required for a 0.7 Probability of Disablement.

Table 8-1A-1 shows the number of hits required, derived from Figure 8-1A-1, for a 0.7 probability of disablement of the major Soviet targets. Reliability of these missiles is accounted for later.

CLASS	TONNES (full)	HITS REQD	NUMBER OF HITTING MISSILES REQUIRED
KIEV	43,000	6.4	7
KIROV	28,000	4.4	5
UDALOY	8,500	1.5	2
SOVREMENNY	7,800	1.4	2
MOD KASHIN	4,600	0.9	1
KRESTA	7,600	1.4	2
KRIVAK	3,800	0.7	1
BEREZINA ADR	40,000	6.0	6
CHILIKIN ADR	24,500	3.9	4

Table 8-1A-1(S) - Hits Required for 0.7 Probability of Disablement.

Various studies, backed by practical experience, have shown that on average 65% of missiles engage the designated target in a multi-target environment, when the missile is used in COMP mode. This must be accounted for when calculating the number of missiles needed to achieve the hit requirement.

CLASS	SEA EAGLES KILLED
KIEV	3.2
KIROV	5.0
UDALOY	2.2
SOVREMENNY	2.3
MOD KASHIN	1.0
KRESTA	0.5
KRIVAK	0.3
BEREZINA	1.8
CHILIKIN	1.0

Table 8-1A-2(S) - Losses to Hard Kill

3.(S) **Losses to Hard Kill.** Table 8-1A-2 shows the number of Sea Eagle missiles which will be lost to a particular ship's SAN and gun systems. A SAN P_k of 0.4 has been used and the data include an allowance for Sea Eagle reliability of 0.9 (this is because missiles with homing head malfunctions can still be engaged by defence systems). The figures shown are the estimated maximum hard kill capability of each class of ship against one wave of Sea Eagles.

4.(S) **Losses to Soft Kill.** Table 8-1A-3 is taken from a study into the effect of ECM on Sea Eagle. It shows the reduction, under ECM conditions, in the number of hits achieved against a 4 ship SAG. The number of hits achieved in the benign environment is represented as 100%; the figures in the last 2 columns show the hit percentage under hostile conditions. In each case 3 attack variations were considered; single, 2 and 3 axes. The ECM had least effect on the 2 axes attack where the hits decreased to 88% and 68% of the benign condition in the 2 hostile environments. The results were particularly sensitive to attack direction and the drastic differences in effectiveness indicated between single and 2 axes attacks are not borne out in other studies, both national and US. What is clear, however, is that a 2 axes attack has the best chance of reducing the effect of soft kill measures. In the case of the 2 axes attack multiplication factors of 1.47 and 1.14 are used to allow for degradation in effectiveness caused by chaff and jamming, respectively with and without decoys.

ATTACK GEOMETRY	SCENARIO		
	BENIGN	CHAFF JAMMING	CHAFF JAMMING DECOYS
Single Axis	100	24	12
2 Axes Split by 90	100	88	68
3 Axes Split by 105	100	67	22

Table 8-1A-3(S) - % of Hits after Soft Kill

5.(S) **Methodology**. Two types of attack are considered: firstly, targeting the HVU when VASTAC is available and the target can be identified for OTHT and secondly, an 'attrition' attack for use when the HVU cannot be selectively targeted.

6.(S) **HVU Attack.** The procedure is as follows: obtain the number of hits required from the right-hand column of Table 8-1A-1. Multiply this number by 1.54 for targeting errors, then by 1.25 to allow for the missile reliability of 80% and then by the ECM factor. The ECM factor is included here as it is only relevant to the number of missile decoyed away from the intended target. Any one wave of missiles is only likely to be engaged by the defensive systems of the target and of the nearest ship on the attack track. The hard kill allowance is, therefore, made up of the summation of the capabilities of the target ship and of one escort per axis of attack (starting with the most capable escort within 15 nm and working down in capabilities as it is impossible to predict where an escort will be at any given time). As yet no study has quantified the number of missiles which are engaged by hard kill and soft kill systems simultaneously. This aspect has, therefore, not been included in the calculations. The method outlined above and the various allowances will be reviewed when a series of studies at BAe, Farnborough and HQ 18 Gp ORB are completed.

Example 1.

Desired target KIROV. Ships within 15 nm				KIEV MOD KASHIN KRESTA
Hits required on KIROV				5
Multiply by accuracy factor (1.54)			=	7.7
Multiply by 1.25 reliability factor			=	9.63
Multiply by 1.47 ECM factor			=	14.15
Add Hard kill	KIROV	5.0		
	KIEV	3.2		
	MOD KASHIN	1.0		
	KRESTA	0.5		= 23.85
TOTAL NUMBER OF MISSILES NEEDED				= 24.

Note: 2 or 3 missiles will hit ships other than the designated target.

7.(S) **Attrition Attack.** When an attrition attack is carried out using selective target modes the above method can, with modifications, provide a guide to the effectiveness of the attack. The target group can be divided into 4 quadrants equating to the left attack axis using near and left and the right axis using near and right. Alternatively only 2 or 3 quadrants could be attacked by varying the targeting or reducing to one attack axis. Targeting accuracy is ignored as miss-targeted missiles will spread at random throughout the target group. ECM and reliability is taken into account. Hard kill losses are calculated by allowing for 1 ship per quadrant (the targeted ship) starting with the most defensively capable ship and working down.

Example 2.

The same group as in Example 1 is attacked with 24 missiles.

Reduction for reliability x 0.8			= 19.2
Minus hard kill losses	KIROV	5.0	
	KIEV	3.2	
	MOD KASHIN	1.0	
	KRESTA	0.5	= 9.7
Then Missiles remaining			= 9.5
Reduction for ECM, multiply by 0.68			= 6.46
Divided by number of ships targeted (ie 4)			= 1.62

Therefore an average of 1.6 missiles will successfully engage each target.

In this case the MOD KASHIN and KRESTA would be disabled and the KIROV and KIEV may be damaged although the missiles targeted at them will absorb the majority of the hard kill losses.

Example 3.

Alternatively an attrition attack may be planned at the outset. In this case it must first be decided which escort is to be disabled and then proceed as shown.

Minimum escort to disable			KRESTA
Hits required (right-hand column)			2
Multiply by number of ships targeted (4)			= 8
Multiply by 1.25 reliability factor			= 10
Multiply by 1.47 ECM factor			= 14.7
Plus hard kill losses	KIROV	5.0	
	KIEV	3.2	
	MOD KASHIN	1.0	
	KRESTA	0.5	
			= 24.4
THEREFORE TOTAL NUMBER OF MISSILES NEEDED			= 25

In this case an average of 2 missiles will successfully engage each target with the better defended ships sustaining less hits and the less well defined ships correspondingly more. If there are more ships in the group than the number of ships targeted then the hard kill losses must be calculated using the best defended ships and the hits assumed to be on the least defended ships.

INTENTIONALLY BLANK

PAVEWAY WEAPON EFFORT PLANNING

1.(S) Figure 8-1B-1 shows the number of LGB hits required for a 0.7 probability of achieving either sinking, immobilisation or neutralization of all weapon systems and the hits in 4 and 6 aircraft attacks.

CLASS	TONNES (Full)	SA-N Types	Nº of ADG	LGB Hits Reqd	LBG Hits 6 a/c	LBG Hits 4 a/c
KIEV	43,000	4 & 3	4	4.1	4.0	2.0
KIROV	28,000	6 & 4	4	3.2	1.0	0.2
KARA	9,700	4 & 3	2	1.3	4.0	2.0
UDALOJ	8,500	9	2	1.1	2.0	0.8
SOVREMENNYY	7,800	7	2	1.1	1.1	0.4
KRESTA II	7,700	3	2	1.1	4.0	2.0
KRESTA I	7,600	1	-	1.1	4.0	2.0
KYNDA	5,550	1	2	0.9	4.0	2.0
MOD KASHIN	4,600	1	2	0.7	4.0	2.0
KRIVAK I	3,800	4	-	0.6	4.0	2.0
PRIMORYE	3,700	-	-	0.6	4.0	2.0
MIKOLAY ZUBOV	3,000	-	-	0.5	4.0	2.0
BEREZINA ADR	40,000	4	2	4.0	4.0	2.0
CHILIKIN ADR	24,500	-	-	2.9	4.0	2.0

Notes:

1. SLAVA and later hulls in KIEV and KIROV classes not included in the study from which these figures were derived.
2. For AGIs, PGGs, LSTs etc use tonnage to derive hits required and closest equivalent ship in defensive systems for hits and losses.

Figure 8-1B-1(S) - Weapon/Target Matching Table - Paveway

INTENTIONALLY BLANK

ANNEX C TO
SECTION 8, CHAPTER 1 OF
TORNADO GR1 TACTICS MANUAL

DEFINITION OF DAMAGE CATEGORIES

1.(R) Ship Damage is currently assessed in terms of Categories A to D which are defined as:

a. **Category A.** Damage which causes immobilisation or sinking of the vessel.

b. **Category B.** Serious damage to the fighting capability of the vessel in the present engagement.

c. **Category C.** Damage likely to hamper subsequent operations - but not likely to affect the present engagement.

d. **Category D.** Minor damage.

2.(R) The shortcomings of this system are:

a. A ship comprises not one weapon, but a number of weapons systems and Category B is too broad to describe accurately the loss of a particular capability.

b. It is often important to distinguish between immobilisation and sinking.

c. Category D has been found to have very limited application.

d. The information available to a formation leader following a Tornado attack will not normally allow this type of categorisation to be made.

INTENTIONALLY BLANK

ANNEX D TO
SECTION 8, CHAPTER 1 OF
TORNADO GR1 TACTICS MANUAL

MARITIME MISSION PLANNING AND BRIEFING SEQUENCE

FIRST BRIEF	WEATHER	General Situation Base En-route Target Diversions Sea State Anaprop Contrail Level Winds Target Area QNH
	INTELLIGENCE/ MISSION PLANS	Overview Enemy Ship Plot Enemy fighter and AWACS coverage Enemy EW FLOT (nearest to target area) Friendly forces, ISRs Available diversions Airspace Control Measures IFF switch on/off lines Airborne Dispersal SAR, E and E
TASKING	LD PILOT	Organise formation to compile brief and mission briefing sheets
	LD NAV	Plan timings and fuels. Pass take off time. Check if AAR needed/sufficient and if timespec achievable. Dep Ld Nav cross-check
	BOTH	Go over plan. Request any changes to AIRTASK via Sqn Exec. Check mission briefing sheets complete
BRIEF	LD PILOT	Mission aim Target and defences Mission briefing sheet domestics
	LD NAV	Route, timing, fuels and EMCON, IFF and silent chop points
	LD PILOT	Attack, RV, recovery, Defensive tactics, Loser and fall-back plans
	Note: Some items may be delegated, eg target brief	
TARGET UPDATE	INTELLIGENCE	Any changes to previous briefs, ACO Reminder of IFF and crypto
OUTBRIEF	EXEC	AC and HAS Management, Airfield state, NBC, damage etc, Sterilisation

INTENTIONALLY BLANK

CHAPTER 2 - AIRBORNE AND POST FLIGHT

References:

A. CINCUKAIR SUPPLAN 50001 M.
B. ATP 34.
C. ACP 160.
D. CINCNORTH SUP 20001 M.
E. CINCUKAIR SUPPLAN 50001 D.

1.(S) **Routeing in the UKADR.** Routeing out of and into the UKADR will normally be via the Transit Corridors (TC) laid down in Annex B to Reference A. The majority of TCs are pre-planned but additional ones may be requested if necessary. Special Corridors (SC) may be established for the use of a large number of missions on co-ordinated attacks or on special operations for which the TCs are not suitable. The procedures on SCs are the same as for TCs. All combat missions entering or leaving the UKADR are to fly along TCs except when under the control of an Air Defence Unit. Aircraft on TCs may be EMCON silent and not receiving any Air Traffic service. There is, therefore, no collision avoidance information available to aircraft on TCs. TCs are 5.4 nm wide and extend from the surface to infinity unless specified in the Airspace Control Order (ACO). TC traffic outbound may use any altitude but must avoid the active Medium and High Level Traverse Levels (TL) by at least 500 ft. TC traffic inbound is to adhere to active TLs. Mode C must not be used when climbing to, at, or descending from a TL. TLs, SCs and TCs are promulgated in the ACO.

2.(S) **Routeing outside an ADR.** Figure 8-2-1 shows the relationship between the UK and ICELANDIC ADRs and the Northern Region Airspace Control Area. The use of the Norwegian Sea airspace outside these areas and further north is co-ordinated by CAEL (COMAIREASTLANT). Routeing in this area is laid down in the ATM.

3.(S) **IFF Procedures.** The IFF codes and procedures to be used by particular types of missions in peacetime, TTW and war are laid down in Reference C. IFF switch-on and switch-off lines are promulgated in the ACO. Outbound IFF is to be NORMAL until the switch-off line at which point it is to be put to STANDBY (the switch-off line will be beyond the switch-on line). NORMAL squawk is resumed homebound when crossing the switch-on line. Between the switch-off and switch-on lines IFF may be operated in NORMAL or STANDBY. Crews must base their decision on the relative risks of engagement by friendly or hostile AD forces. The IFF procedures in the CINCNORTH sub-areas are subtly different from the UK procedures and are contained in Annex E to Reference D.

4.(S) **Co-ordination with Ships Air Defences.** Ships air defences can be considered under 3 headings:

a. **Ships With Organic Air Assets.** CVs carry their own air defence assets. Their OTCs will advise the AHQs and MHQs of their Co-ordinated Air Defence Areas (CADAs) and will take responsibility for all air defence within the CADA, even if within an ADR.

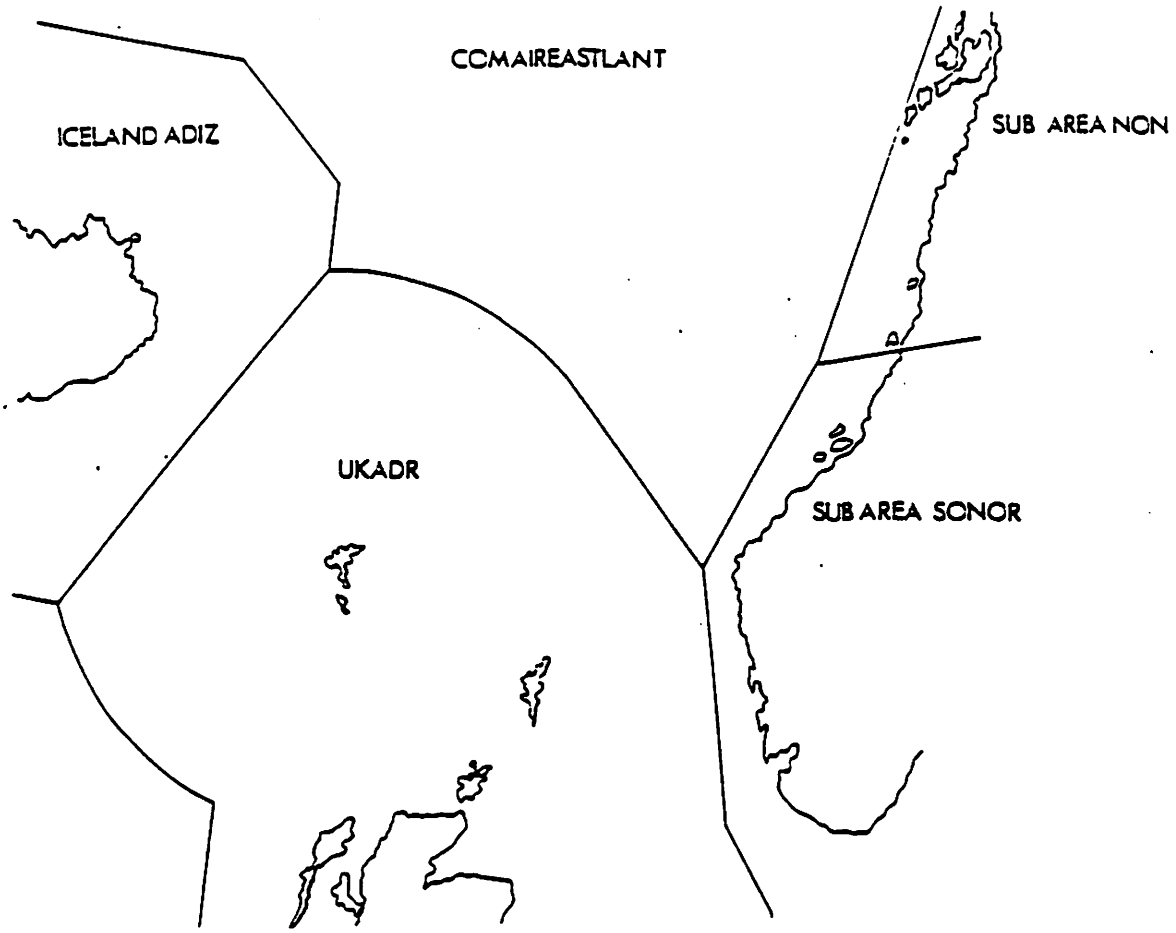


Figure 8-2-1 (S) - Control of Airspace

b. **Ships With Non-Organic Air Assets.** An OTC may request an AHQ to provide land-based air-cover to operate under his control.

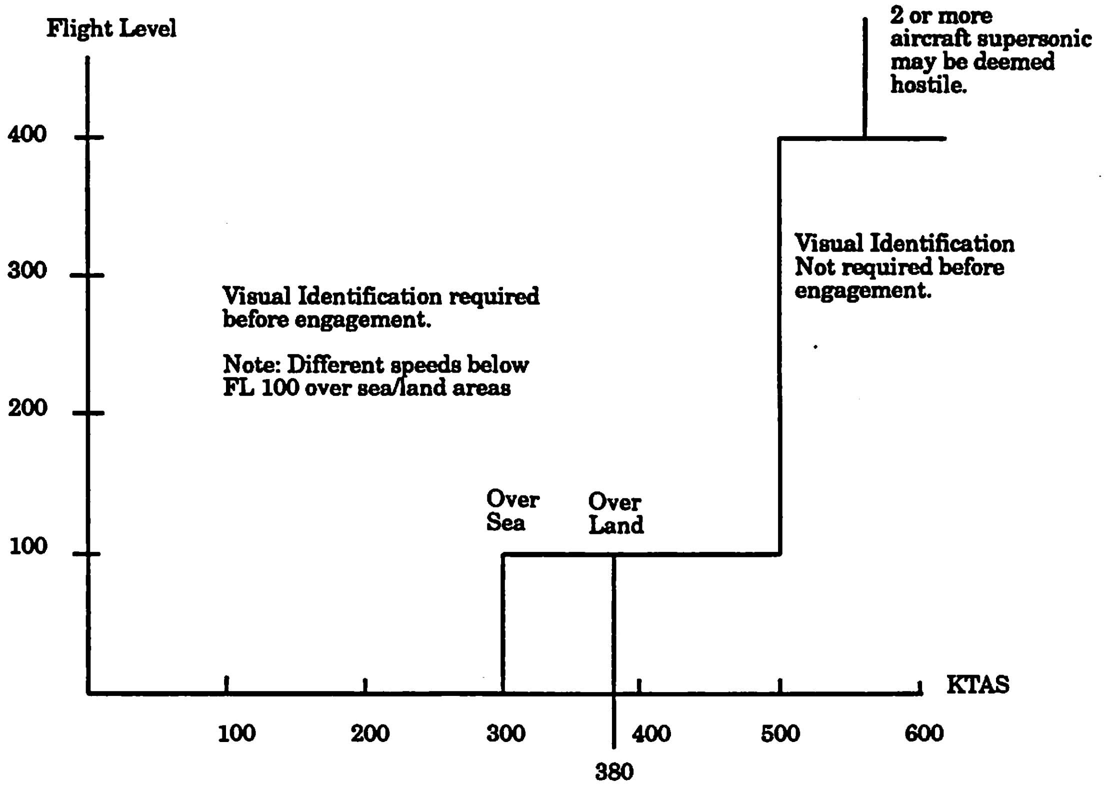
c. **Shipborne Defences Only.** Ships defended only by their own SAMs and guns.

The OTC will specify IFF and contact procedures for aircraft needing to penetrate the CADA. Where land-based fighters are concerned co-ordination will be through the UKAIR Maritime Air Defence Cell (MADC) in the Northwood Operations Centre (NOC). Co-ordination is procedural for ships using only their own defences. An Identification Safety Range (ISR) is specified in the ATM for each friendly force and is normally 60 nm from the ZZ. Aircraft must not penetrate the ISR unless cleared by the Anti-Air Warfare Co-ordinator (AAWC). An OTC may also request a Restricted Operations Zone (ROZ), in accordance with Reference A, to sanitize airspace along the track of his force. All these procedures depend upon communications between OTCs and the MHQs. The problem is what to do when communications break down and you are unexpectedly illuminated by a friendly search or fire control radar. Crews should turn away and ensure they are squawking the in-use codes.

5.(S) **Co-ordination With AD Agencies.** The MADC is set up to co-ordinate the routeing needs of strike attack and MPA aircraft with the relevant AD agencies, including OTC's, UKADR and adjacent ADRs.

6.(S) **Maritime ACOs.** The AD Commanders' ACOs are not passed to OTCs and the SUPPLANS MIKE are rarely held by ships. UK based squadrons will only receive the UK ACO. Exercise TEAMWORK 88 highlighted many problems with airspace management and co-ordination. It is likely that more emphasis will be given to airspace co-ordination measures in future exercises, including JMCs.

7.(S) **Autonomous Fighter Operations.** Current UKADR fighters are not capable of identifying aircraft by electronic means or track recognition. To provide them with a BVR capability during autonomous operations they are given height and speed engagement criteria. Figure 8-2-2 (taken from Reference E) shows those criteria. Crews outbound from UKADR at low level are unlikely to be engaged BVR by an autonomous fighter. Inbound, part of the problem is knowing if any friendly fighters are operating autonomously. Crews must therefore keep within the height and speed restrictions until they are in contact with an AD agency. The other part of the problem is what to do if engaged BVR by a 'friendly' fighter. If missile launch is indicated the only option is to evade first and then attempt to make contact on Guard. If the RHWR detection is just a radar in search or a short CW range lock then any evasion or jamming would be construed by the fighter as hostile behaviour. Therefore crews should maintain 'friendly' height and speed parameters and use Guard if necessary. The problem is compounded by RHWR ambiguities and crews must have a good knowledge of the intelligence situation if they are not to over-react or, more importantly, under-react.



Note: The North Sea south of 55° N and Denmark and the Skagerrak east of 08° 15'E are classed as overland areas.

Figure 8-2-2 (S) - Autonomous Fighter Engagement Criteria

8.(S) **BRICKWALL Procedures.** Aircrews suspecting IFF failure or experiencing an emergency AND who are unable to comply with activated Airspace Control means should first attempt to contact an AD or ATC agency or NAEW aircraft on the wartime TAD frequencies. Only if this fails should the BRICKWALL procedure be used. Crews must be familiar with authentication procedures and have the tables to hand when attempting to contact any agency.

9.(S) **BDZ.** UK BDZ procedures are laid down in Annex C to Reference A. The majority of UK BDZs are non-standard and all have codenames for the various safe-lanes. Crews must note that the no-radio or LAME-DUCK procedure for all BDZs includes making an easterly approach to the airfield with a teardrop to the south from the overhead if the westerly runway is in use. If recovering to a European airfield and unable to follow local procedures LAME-DUCK procedures must be used.

10.(S) **Reporting.** The following 2 types of report are required from MTW aircraft on TASMO missions:

a. **TASMO IN-FLIGHT REPORT (INFLTREP).** The INFLTREP is to be transmitted directly to the agency specified in the ATM, or if necessary relayed by friendly aircraft to ships or shore stations. It is important that it is transmitted as soon as possible after the attack as it is a major contributor the intelligence picture and because it may alter the tasking priorities for future missions. For Sea Eagle missions the results given should be a statement of the number of missiles fired at the target location and the type of targeting, eg 'VASTAC' or 'own radar', and any further information available on the target identity and effectiveness of attack.

b. **TASMO MISSION REPORT (MISREP).** The MISREP, including sensor read-out, is to be completed within 30 minutes of engine shut-down. If sensor read-out, eg TIALD tape analysis, is not completed within 30 minutes then further information or significant changes to the MISREP should be reported by a RECCEXREP.

The format for all TASMO messages are in Reference B, Chapter 8.

CHAPTER 3 - TARGET LOCATION AND IDENTIFICATION

TARGET LOCATION

1.(C) **Introduction.** MHQ Northwood has access to a variety of sources of information on target locations ranging from EW and radar satellite information, through HF DF, reports from ships, submarines and MPA to strike/attack IFREPS. With all this information available target location should be simple but in practice it isn't. The use of tactics such as deception groups, long-leg zig-zags and hiding in weather clutter all serve to confuse the overall plot. For the maritime attack formation the difficulty in locating the tasked target varies because:

a. Estimates of the target position at the TOT depend on the accuracy and time of the last positive fix on the target and on the estimate of the target MLA at the time.

b. The target reporting unit may have navigational inaccuracies.

The attack can be carried out using a target location from a third party or a Tornado Probe or by the formation itself locating the target starting with the ATM information.

ATTACK SUPPORT

2.(R) **Shadower.** An aircraft or ship observing and maintaining contact (not necessarily continuously) with an enemy ship or surface action group (SAG) is called a shadower.

3.(C) **Attack Support.** Attack Support is the general term for the tactical assistance given by the shadower to enable attack aircraft to locate their target. The attack support procedures are at Annex A. There are two kinds of Attack Support operations:

a. **Tactical Direction (TACDI).** TACDI is a form of attack support in which the target position is reported by the shadowing aircraft, either by SURPIC or by bearing and range from a pre-arranged GATE position. SURPIC procedures are at Appendix 1 to Annex A.

b. **VASTAC.** VASTAC is the vectoring of attack or probe aircraft onto specified enemy ship targets. This procedure requires the shadower to have radar contact with the target and both radar and RT contact with the attack aircraft. The shadowing aircraft vectors the attack aircraft until they reach the weapon release point or can continue independently. VASTAC procedures are at Appendix 2 to Annex A.

4.(R) **Visual Reconnaissance Probe.** Visual Reconnaissance Probes (VRP), are aircraft used by Maritime Air Surface Surveillance (MASS) aircraft to identify selected radar contacts visually.

5.(R) **Procedures.** The detailed procedures used within NATO in attack support are contained in AXP 5B, EXTAC 322. However, not all agencies are as familiar with or as adept at EXTAC 322 procedures as is the Nimrod force. AEW assets in particular often insist on a 2-way dialogue rather than a broadcast form of control. It may even be necessary, having established contact with a shadower and authenticated, to ask for un-encoded range and bearing to the target. AXP-5B should still be used when operating with NATO forces.

6.(C) **Attack Support Resources.** Several agencies may be tasked to provide attack support for a Tornado attack, namely:

a. MPA may be tasked to provide attack support. Aircraft such as the P3 Orion cannot identify aircraft at low level and are limited to giving tactical direction. The Nimrod MR Mk2 and Sea King AEW (SKW) can detect aircraft IFF and therefore may be tasked to provide VASTAC.

b. Lynx and Sea King ASW (SKJ) helicopters from a RN ship may be tasked to provide tactical direction. They will use SURPIC procedures only.

c. AEW aircraft have a radar that can detect low flying aircraft and may be tasked to provide attack support. AEW codewords are listed at Annex B.

d. If no other support is available, Tornados may be tasked in the probe role to locate and give tactical direction for a subsequent attack.

7.(R) **Detached Probe.** If attack support information is not available to the attack leader, or is inadequate, and fuel considerations permit, he may detach probe aircraft to check on the identity and disposition of hostile ships. Exceptionally, when the target needs to be located, the leader may use his formation to search for the target (see para 11c below).

TORNADO SEARCH

8.(R) Aircraft used for probe missions may be configured in any of the standard loads.

9.(C) The rules given below should be followed at all times:

a. Treat all ships as hostile warships unless positively identified as friendly.

b. Do not approach closer than 50 nm to friendly ships unless tasked to do so.

c. If an approach closer than 20 nm to friendly ships is required, 2-way RT communication must be established and the aircraft positively identified using the identification/ recognition procedures detailed in ATP 1 (B) Vol 1, para 1542. If such an approach is made inadvertently, follow the procedures concerning 'Blue on Blue' outlined in Chapter 2, para 4.

d. Whenever approaching closer than 20 nm to hostile or possibly hostile shipping:

(1) Fly at 500 kn or above.

(2) Fly as low as possible.

(3) Select the Skyshadow pod ON, if RHWR threat indications within pod coverage.

(4) Approach no closer than is required to achieve the aim.

10.(C) **High-Level Search.** Occasionally it may be necessary to conduct a high-level search. This should only be done when a large area of ocean has to be covered and the density of shipping is low. The RHWR should be the primary means of target detection, but the GMR may have to be used if the target is running silent. A search pattern should be constructed using the capabilities of the GMR shown in Table 8-3-1, and in the light of current intelligence.

11.(C) **Unexpected Detection of Target.** If, during a high level transit, the RHWR shows EW radars which indicate detection of the target, swift action is called for. A descent should be initiated to get below the target's radar horizon. The implications of early detection of the target are that: it is closer than originally thought, that the planned TRU is not in place or is unserviceable and that you now have some fuel and time in-hand. Having noted heading and target relative bearing from the RHWR, a turn can be made away from the target to skirt round its radar horizon. A further relative bearing from the RHWR will now give a 2 position line fix of the target's position.

12.(R) **Low-Level Search.** When a probe is operating without the benefit of an Attack Support aircraft, the normal method of finding the target will be a low-level search based upon the target's DR position.

a. **Search Pattern.** When the target is not found at its DR position the search should begin from that point, back tracking the reported MLA; experience has shown that if a target is not at its DR position it will probably have failed to reach that point rather than to have travelled beyond it. The dimensions of the search should be planned using the following information:

(1) The intelligence assessment of the target's intentions.

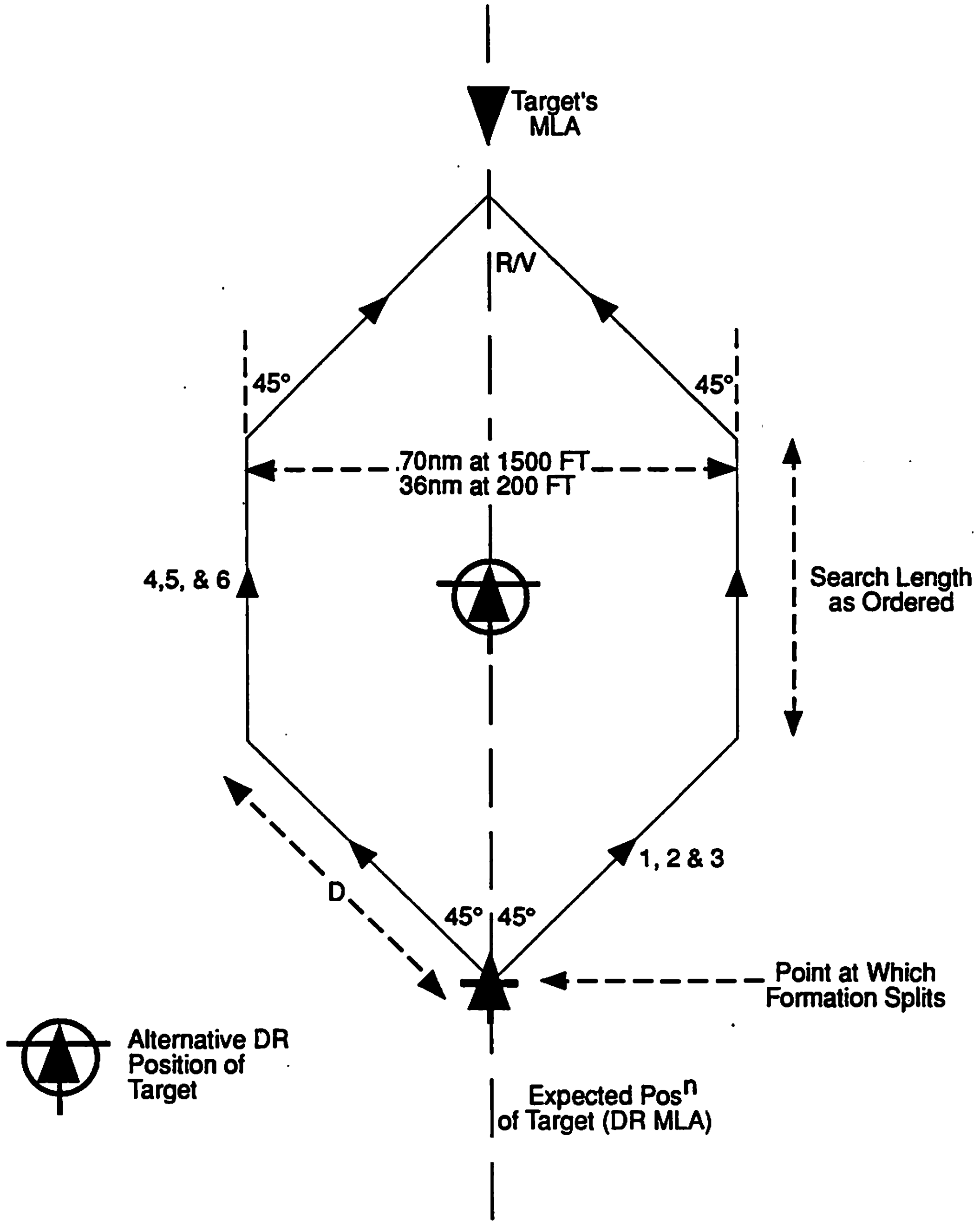
(2) The confidence which can be placed on the target's DR position. A speed of 15 kn or more tends to indicate that the ship is in transit to a specified area of operations, whereas at speeds lower than 15 kn it might be, for example, engaged in an ASW search pattern, or just maintaining steerage way to stay on station.

Target Size	Large/Medium eg Cruisers	Medium/Small eg Destroyers/Frigates
Best height to fly (Feet)	2,600	2,900
Radar horizon/(maximum detection range) on GMR (nms)	80 (75)	80 (75)
Scanner depression	2°	2°
Practical width of swept path with 45° scan (nms)	73	73

Table 8-3-1(C) GMR - Optimum Height and Range for Initial Target Detection for a 100ft/50ft Mast High Target

b. **Search Technique.** At 2,900 ft GMR has a range of about 75 nm against a 50 ft mast height target and there is little point in flying higher to achieve greater search ranges. The GMR has a practical scan of 45°, out to a detection range of 52 nm, this will give a sweep of 36 nm either side of the aircraft's heading. Therefore, the Tornado could be detected by enemy ships to its flanks, without itself being aware of them; however it should be outside all MEZs with the possible exception of SA-N-6. Where a high level of identification is required the aircraft may have to close to visual range. In this case the profile illustrated at Figure 8-3-2 should be followed. The Tornado is poorly placed for a visual probe against enemy ships armed with SA-N-6 and SA-N-7 as the visual identification range will normally be inside their MEZs. The Tornado, however, should be able to remain below the MEZs of SA-N-1, SA-N-3 and SA-N-4 and outside the MEZ of SA-N-9. In crowded shipping lanes the aircraft would have to make frequent identifications, thereby disrupting the search pattern, reducing the width of the scan, and possibly searching the flanks inadequately. In such circumstances search heights lower than 2,900 ft are necessary, and 200 ft ASL affords a reasonable compromise between the avoidance of MEZs, the demands of low flying, and the achievement of adequate GMR coverage. At this height the radar horizon for a 50 ft high target is 26 nm and the usable scan of GMR in 45° scan is 26 nm either side of heading.

c. **Formation Search**. The practical formation search patterns are illustrated at Figure 8-3-1. If the attack formation does not find the target at the DR position, a search should start from this point and back-track the reported MLA. If the target's DR position is in doubt before the attack formation takes off, a search should be anticipated and pre-planned accordingly. In such cases the DR position should be in the centre of the pattern (alternative in Figure 8-3-1) so as still to allow single direction search whilst allowing for the greater uncertainty in predicted target position. The search direction should still back-track the target's MLA; when the MLA is unknown the leader must use his own judgement, based on the best intelligence available, to determine the direction of search. A formation should not be split into more than two groups while conducting a search because it will become too widely dispersed to control and to reform for an attack. The search datum is the point of split, the search legs being flown parallel to the track at the time of split. When ordering a search the formation leader must specify the length of the pattern in terms of minutes along the search legs; a typical order to search being: "C/S, SEARCH ONE, FIVE MINUTE LEGS, GO". The airspeed should be 360 knots, being a reasonable compromise between range and endurance speeds at average weights and store indices. Contact positions should be given as a bearing and distance from the datum (point of split). Having flown the search as ordered the formation should rendezvous as shown in Figure 8-3-1. If the target has been located any RV will be called with respect to the split point. If the target has not been located a further search should be flown from a new datum. The RHWR should be in use throughout the search.



'Search 1' 200 Feet ASL - D = 4 mins 10 secs } Time from Split to Start of Turn onto Search Leg

'Search 2' 1500 Feet ASL - D = 8 mins 10 secs }

Note; All Turns 60° Bank. IAS 360 Kn

Figure 8-3-1(R) - Search Patterns

d. **Anaprop.** Anaprop conditions regularly exist in the North and Norwegian Seas in Spring and Summer and in all warmer latitudes throughout the year. If Anaprop conditions are suspected then the radar should be selected to transmit at low level and different range scales selected. This may obviate the need for a split formation search or for a climb to increase radar range. However, the enemy's detection of you is also made easier in Anaprop conditions and it may be necessary to climb out of the surface duct to become obscured to enemy surface search radars.

PROBE TACTICS

13.(C) The technique used by a probe at low level varies according to the intelligence required, the weather conditions and the state of tension or hostilities prevailing. Because of its vulnerability, the probe must pass information back to the attack leader, MASS aircraft or MHQ as soon as it is available by any means at his disposal. It is particularly important to pass an initial target position before closing to identify. This will ensure that at least a target position is available should the probe be destroyed subsequently. Following a low-level visual identification run, the probe should transmit a consolidated SURPIC message. The probe should remain in the target area for as long as fuel will permit to monitor target movement and disposition, particularly if no other shadower is available. Subsequently the probe may be used to make a diversionary attack (see para 16).

14.(R) **Time of Tension.** In time of tension the probe profile should be unprovocative. The aircraft should fly abeam the ship, at slow cruising speeds at around 500 ft ASL, to increase the field of view and the time available for identification. The probe should fly no closer to a vessel than is necessary to achieve the degree of identification required, and where possible it should avoid flying directly towards any vessel. The probe crew must be meticulous in their observation of the briefed ROE.

15.(C) **During Hostilities.** After the start of hostilities the probe must be at low level by 40 nm from the nearest contact. Once the suspect target or SAG has been acquired on radar or ESM equipment, the crew must select a route through the target area which will allow the required identification of the suspected primary target and as many of the other contacts around it as possible. As it passes through the target area the probe must try to stay outside the envelopes of the targets' defences. The ability to remain clear of defences will depend on whether visual identification is required and the visual conditions pertaining at the time. At visibilities of between 10 and 20 nm a ship can normally be detected at about 0.8 of the visibility distance, and identified by the unaided eye at a range between one half and one third of the visibility; use of TIALD will permit identification at greater ranges. As visibility decreases, unaided identification is possible at ranges progressively closer to the detection range; below 7 nm visual detection and identification ranges are likely to be equal. This information is useful for planning the probe track if the visibility in the target area is known to be good and the probe is able to navigate accurately to the target area. If the visibility is not known accurately, the probe crew should note the radar range at which the target is visually detected and plan their subsequent track so that the closest approach to any ship suspected to be hostile is between one half and one third of the detection range. This may necessitate flying through or below SAM or AAA envelopes, in which case the aircraft should be flown as low as possible, and at about 520 knots. The RHWR should be in operation throughout the identification pass as it may give warning of attack by SAM or AAA. Whenever possible, the probe's track should be planned so that the ships are on the same side of the aircraft as the

Skyshadow pod to reduce blanking problems. Once a ship has been identified, a breakaway at not less than 3 'g' should be flown, unless it is necessary to maintain track to identify other contacts.

DIVERSIONARY ATTACKS

16.(C) If the probe is operating with a Sea Eagle attack its missiles' TOT should be the same or later than that of the attacking formation. When the probe is operating in conjunction with a Paveway attack formation, and if fuel permits, a diversionary attack should be carried out by the probe ahead of the main attack. Experience in the MBW has shown that this causes considerable confusion and increases the workload on the defence system operators. The optimum timing for the diversionary attack is for the probe to be between 10 and 20 nm ahead of the main attack. Co-ordination may be effected by the attack leader transmitting the code word "VIPER", on the UHF and HF TACDI frequencies, when at an estimated 70 nm from the target. The probe then positions to be between 30 and 40 nm from the target 3 mins after receiving the code word. The probe should aim to spend a period of time beyond the target's radar horizon prior to commencing the diversionary attack. The actual line of attack (LOA) is not important, but it should be separated by at least 60° from both the LOA of the attack formation and from the run-out track used after the completion of target identification. The diversionary attack should be made as follows:

a. Run from 30 nm at 540 kn on a straight track towards the target. The GMR should be on and in 30° scan, centred on the target.

b. Height should not exceed 100 ft ASL when within 20 nm of the target.

c. Break off the attack at 10 nm by making a level turn at 3 'g' or more. Chaff should be used to help confuse the enemy's air picture.

CLASSIFICATION AND IDENTIFICATION OF TARGETS

17.(C) **Introduction.** Target detection and classification are the basis for all surveillance missions. Visual identification provides the most definitive classification, but may not always be authorised. Variances in aircraft capability (eg imaging versus conventional pulsed radar, FLIR, ESM capability etc) will determine the accuracy and completeness of the surface plot developed. Nonetheless, to mount an attack or initiate shadowing operations, some form of classification is necessary. There are three elements in contact classification:

a. Characteristic. eg. surface.

b. Category. eg. hostile, neutral, friendly or unknown.

c. Type. eg. class or name, combatant or non-combatant.

Associated with contact classification are appropriate definitions and confidence levels which are explained in para 19.

18.(C) **Identification Methods.** Tasking authorities must determine the level of identification required. Visual identification provides the best information but is the most hazardous in times of tension or war. Stand-off identification alone will invariably achieve a lower level of classification.

a. **Visual Identification.** In times of tension or war VRP aircraft will be assigned to visual identification tasks. In peacetime or in a low threat environment the surveillance aircraft may be authorised to self-probe by the OTC/AHQ/MHQ depending on the ROE in force.

b. **Stand Off Classification.** Aircraft equipped with radars having a profile capability (eg

Nimrod Mk2, ISAR P3, S3B and SKW), Electro-Optical or direct imaging infra-red systems, ESM systems or a combination of such sensors can be considered capable of achieving a lower degree of target identification than that obtained visually. However, this can be achieved at stand-off ranges with a lower degree of risk to the aircraft. Combining this information with the contact reports from surveillance aircraft and other sources may provide the data necessary to complete the surface picture compiled by the OTC/QHQ/MHQ.

The tasking message must clearly state the type and the level of identification required and must state whether visual identification is authorised.

19.(C) **Classification/Confidence Rating.** An additional factor to the following levels of identification is the degree of confidence assigned by the surveillance aircraft to its contact. For guidance, the criteria on which classification and confidence ratings are based are set out below in Table 8-3-2 and expanded upon below.

a. **Certain Identification (CERT).** A contact that has been positively identified by competent personnel, visually or electro-optically, and continuously tracked after initial identification.

b. **Probable Identification (PROB).** A contact that has been positively identified to naval class using an imaging radar and is supported by evidence from another sensor or good intelligence. Naval class is defined as a specific type or series of ships all built to the same basic design. Examples include FORRESTAL class aircraft carriers, Type 42 destroyers and KIROV class cruisers. In other words, the image interpretation by the aircraft crew has positively identified the unit, and no other unit could possibly be interpreted as that one. Imaging radars are extremely good at defining a particular naval class of ship, but are unable to distinguish between ships of the same class unless they have very noticeable physical differences. Thus an imaging radar can easily identify a KIEV class contact, but would be unable to differentiate between the KIEV and the BAKU, 2 different ships of the same class.

c. **Possible Identification Confidence High (POSS CONF HIGH).** A contact that has been positively identified to naval class by an imaging radar, but there is no other supporting evidence other than the radar image that this is the identity of the contact. This classification level can also be reached by a non-imaging radar that has been corroborating ESM that is unique to that particular class of ship.

d. **Possible Identification Confidence Low (POSS CONF LOW).** A contact that has been identified by an imaging radar to perceptual class. Perceptual class is defined as that level of image quality which allows only interpretation to one of the following 4 classes:

(1). Combatant - this includes warships of all sizes.

(2). Mership/Auxiliary - this class includes tankers, bulk carriers, freighters, large fishing vessels and military vessels such as AOs, AEs etc.

(3). Landing Platform - this class includes any ship with a large flat deck unencumbered with cranes, etc, from which aircraft can be launched or recovered.

Examples would include CV, CVH, CVS, LPH.

(4). Small Craft - this class includes any contact whose length (less than 200 ft) makes classification difficult.

This classification level can also be achieved by using a non-imaging radar that has corroborating ESM that is known to be fitted on that class of ship, but is also carried on ships of other classes.

e. **Unknown (UNK).** A contact is Unknown where the quality image is marginal or non-existent as a result of the aspect angle, target size/location, radar range, weather, or where there is no corroborating information or intelligence available in the case of a non-imaging radar.

CLASSIFICATION	HOW OBTAINED
CERT	Contact which has been sighted and positively identified by a competent observer.
PROB	Classification using an imaging sensor to naval class supported by evidence from another sensor or good intelligence.
POSS CONF HIGH	Classification using imaging sensor to naval class. Or Non-imaging radar with corroborating unique ESM.
POSS CONF LOW	Classification using an imaging sensor to perceptual class (Combatant, Mership/Auxiliary, Landing Platform, Small Craft) Or Non-imaging radar but with intelligence or corroborating non-unique ESM.
UNK	Contact about which the operator is unsure.

Table 8-3-2(C) - Contact Classification Matrix

20.(C) **Use of Classification/ Confidence Rating.** Units involved in ASUW operations are likely to use the level of identification or the classification of contacts in decision making. For example, before launching an air attack, a PROB classification might be required. This will be stated in the ATM. On the other hand a POSS HIGH rating might only merit shadowing, perhaps with more capable aircraft. Decision making in such circumstances is made easier by correct and accurate reporting. All aircraft must ensure that in-flight reports (including SURPIC) accurately reflect the contact classification achieved.

INTENTIONALLY BLANK

ATTACK SUPPORT

1.(U) The following procedures provide standard methods by which a TRU gives assistance to strike/attack aircraft.

2.(C) **Initiation.** Attack and Attack Support operations will be ordered by an AHQ/MHQ for land based aircraft and by the OTC/ASUWC when carrier based aircraft are employed. All land based and co-ordinated operations between land based and carrier based maritime aircraft will use FORM TURQUOISE. Where appropriate, targeting and optimum asset utilisation will be agreed by the ashore and afloat commanders.

3.(C) **Ordering the Mission.** Attack Support Operations will be tasked using FORM TURQUOISE at Appendix 3. The following information is to be included in the tasking message as default criteria:

a. Missile Time on Target (MTOT) (Zulu).

b. **Gates.** A specific gate will be assigned to each individual attack force. It will be given as Bearing and Range from the Last Known Position (LKP) of the target. Organic air assets may require the gate to be specified relative to a designated unit or position (eg the CVSG). The gate will be provided on the FORM TURQUOISE or, in the case of organic air assets, by the TRU. In the case of two attack groups, the spacing between the gates will be dependent on the capabilities of the TRU (ie, their ability to detect and hold the attack aircraft and the target simultaneously). Table 8-3A-1 refers. Exceptionally, the TRU may need to alter the position of the gate for tactical or safety reasons (eg, proximity of land or enemy MEZs). The new gate position will be ordered in para F2 of the SURPIC message as a COVEC bearing and range from the Reporting Point.

Nimrod	120 nm
P3	80 nm
P3 ISAR	200 nm
E3	200 nm
E2	200 nm
Aurora	120 nm
Atlantique	80 nm
Sea King W	120 nm
S-3A	100 nm
S-3B	100 nm

Table 8-3A-1 (C) - Maximum Gate Spacing for Shadowing Platforms

c. **COVEC Values.** COVEC is used to disguise ranges and bearings passed on insecure radio nets. The COVEC values to be applied will be specified in the tasking message, are always positive, are given as multiples of 5 and with a minimum bearing addition of 40 degrees. All bearings and ranges to which the ordered corrections have been applied are prefixed 'COVEC'.

4.(C) **SURPIC.** SURPIC requires a shadowing aircraft to broadcast target position using the message format described in Appendix 1 to this Chapter.

5.(C) **VASTAC.** The term "VASTAC' is not used in the current EXTAC 322. The vectoring information is included in the abbreviated SURPIC message shown at Appendix 1 to this chapter. Attack procedures are shown at Appendix 2.

However, VASTAC procedures will be re-introduced in the next amendment to EXTAC 322.

SURPIC

1.(R) **Purpose.** SURPIC is a voice message procedure for reporting the position and disposition of a contact or group of surface contacts during shadowing or targeting operations. It is used primarily to provide a SURface PICture during shadowing operations and also provides sufficient data for an attack to be carried out. A message format is at Table 8-3A1-1; an example message at Table 8-3A1-2.

2.(C) **Method.** Radar contacts in the target group are reported by bearing and range from the High Value Unit (HVU) which is designated as the SURPIC Reference Position (RP). If the HVU cannot be recognised, the contact nearest to the centre of the group is used as the RP.

3.(C) **Reference Position (RP) (Para A).** The position of the RP is normally to be reported as GEOGRAPHIC (ie, in latitude and longitude in clear). An alternative method of reporting the RP is RELATIVE (ie, bearing and range from a designated unit or position). This method is only to be used if specifically ordered in the tasking message.

4.(C) **Position Accuracy (Para B).** The estimated accuracy of the RP is to be denoted by an accuracy suffix selected by the reporting unit from the following:

X-RAY	within 2 nm
YANKEE	within 10 nm
ZULU	worse than 10 nm
GOLF	GPS derived position

5.(C) **Data Time (Para C).** Data time is the time (Zulu) of the target's Last Known Position (LKP).

6.(C) **Disposition (Para D).** Surface contacts are reported in paragraph DELTA of the SURPIC message using an unencrypted bearing (deg) and range (nm) from the RP. The target located at the RP (normally the HVU) is always reported first. In the absence of specific instructions, the TRU is to report all radar contacts within 30 nm of the RP and any potential threat within + 60 ° of the gate-to-target axis; additional contacts may be reported when so ordered or at the discretion of the TRU.

a. **Contact Serial Number/ Track Number.** Contact serial numbers (01-99) are selected by the TRU and remain specific to the contact reported. If the HVU changes, serial 01 will reflect the change, but contacts will retain their origional serial number.

b. **Confidence Level.** Reports must accurately reflect the degree of indentification achieved and associated confidence levels. (Chapter 3, paras 17-20).

c. **Contact Designators.** Contacts are to be reported using the designations agreed in STANAG 1166. Selected designators have been taken from Edition 4 of the STANAG and are at Table 8-3A1-4.

7.(C) **Target Mean Line of Advance (Para E).** The mean line of advance (MLA) of the target group is to be reported (degrees true/speed in Knots) in para E. Significant variations, from the group MLA shown by individual units may be included in para F.

8.(C) **Weather Report/ other information (Para F).** Para F should include that information which, in the absence of any further attack support would enable the attack to take place. The paragraph is as follows:

F1. Any alteration to MTOT (passed as a plus or minus figure on the MTOT ordered in the tasking message).

F2. Changes to Gates. Given as a COVEC bearing and range from the RP.

F3. Weather. To include wind, temperature and any known areas of turbulent cloud that may affect the attack run.

F4. Egress Left/Right. F6 is a B52 specific field; passed to enable a B52 attack force to avoid any potential threat.

F5. Information about organic air gate assignement given as a COVEC bearing and range from a designated unit or position.

F6. Any other information.

9.(C) **Repeat of RP (Para G).** Para G is a repeat of Para A.

10.(C) **Authentication.** SURPIC messages are authenticated.

11.(C) **Broadcast Schedule.** A standard broadcast schedule is at Table 8-3A1-5. In the absence of other instructions, the reporting unit is to broadcast SURPIC reports in accordance with this standard schedule.

12.(C) **Abbreviated SURPIC or VASTAC.** The Abbreviated SURPIC message contains the COVEC bearing and range of the target (RP) from either the Gate or the attacking aircraft, as applicable. It also contains an updated RP position and MLA (paras A and E from the SURPIC message). An example message is at Table 8-3A1-3.

Note: In the next amendment to EXTAC 322, VASTAC will replace abbreviated SURPIC. There will be a separate frequency allocated for VASTAC broadcasts.

13.(C) **Deceptive Reports.** Deceptive VASTAC reports will be transmited on a VHF frequency on a random basis. Deceptive VASTAC will not be transmitted on the briefed VASTAC frequency or its backup.

14.(C) **Information Update.** The SURPIC schedule requires information on position, course and speed to be updated every 10 minutes. The remaining information in the full SURPIC message only is to be updated at 20 minute intervals.

THIS IS (C/S)

SURPIC

A (Reference Position)

B - - (Position Accuracy)

C - - - - Z (Data Time)

	Ser/Trk No	Bearing/Range	Level of Confidence	Ident Designator
D				

E (MLA degrees/knots)

F
1 ....Changes to MTOT
2 ....Changes to Gates
3 ....Surface Weather
4 ....B52 Egress Left or Right
5 ....Organic Air Gate Assigament
6 ....Any other information

G (Repeat of Para A)

AUTHENTICATION (At time of transmission)

Notes:

1. The field element will always be 000/00 and is, therefore, not transmitted.

2. Contact Serial Numbers (1-99), once allocated remain in force with that designated contact throughout the period of support. If the HVU changes, serial 01 will reflect the change, but contacts will retain their origional serial number.

3. The message must be broadcast at a speed slow enough to allow the receiving aircraft to copy it down.

Table 8-3A1-1(C) - SURPIC Message Format

EXAMPLE SURPIC MESSAGE

		MEANING
This is	J9G	Transmitting aircraft callsign
SURPIC		Message identifer
ALPHA	5913N 01410W	Reference Position (Position of HVU). Reported as: GEOGRAPHIC OR RELATIVE (bearing and range from designated unit or position).
BRAVO	YANKEE ALPHA	Position accuracy 3 nm.
CHARLIE	1515	Data Time
DELTA		Contact Ser No, Brg & Range/Ref Pos, Ident
	01/Prob CHARLIE VICTOR	Serial 1 (HVU) Prob Carrier .
	02/350/4/Poss Low JULIET VICTOR	Serial 2 Brg 350°/4 nm from the RP Poss Low, Large Warship
	03/355/5/Poss Low JULIET XRAY	Serial 3 Brg 355°/5 nm from the RP Poss Low, Small Warship
ECHO	210/20	Group MLA 210/20
FOXTROT		
	ONE/Nil	There is no alteration to the Missile Time on Target.
	TWO/Nil	There is no change in gate position.
	THREE/270/15/+5/8 Octas 1000 ft/3 nm	Weather at Aircraft Position.
	FOUR/Nil	Nil (No B52s this time).
	FIVE/XRAY TWO MIKE/ COVEC 150/ 180	In this example organic air assete are being employed and the TRU has nominated the gate position in COVEC relative to C/S X2M (the CVSG)
GOLF	5913N 01410W	GOLF is repeat of ALPHA
	Authentication PAPA DELTA	Transmission authentication

Note: In voice transmission use "Tack" where "/" is indicated.

Notes:

1. COVEC will be referenced from the Gate until a valid IFF response is observed by the TRU.

2. When multiple attacks are ordered, the TRU will broadcast a complete Abbreviated SURPIC to the attack group. Paras A and E may be reported as "SAME". Differentiation will be reported as "Gate 1" and Gate 2" and so on. Gate differentiation will be detailed in the tasking message.

Table 8-3A1-2(C) - Example SURPIC Message

EXAMPLE ABBREVIATED MESSAGE		**MEANING**
This is	A4X	Transmitting aircraft callsign
SURPIC	GATE 1, STANDBY, MARK, COVEC 265/125	Target bearing 265/ range 125nm from attacking aircraft squawk.
ALPHA	6208N/ 01055W	Reference Position of HVU
ECHO	090/ 15	Group MLA 210/20
Authentication	PAPA DELTA	Transmission authentication

Table 8-3A1-3(C) - Example Abbreviated SURPIC Message

General Type	Specific Type
AA - Auxillary	AA - Auxiliary AGI
	AO - Oil Tanker, general
	AS - Submarine Tender
	AK - Cargo Ship, Naval
TM - Merchant Ship	TMB - Bulk Carrier
	TMP - Passenger Ship
	TMO - Tanker
	*TMZ - Oil Rig
TU - Fishing Vessel	TUF - Fish Factory Ship
CC - Cruiser	CG - Guided Missile Cruiser
CV - Aircraft Carrier	CVH - Helicopter Carrier
	CVS - ASW Support Carrier
DD - Destroyer	DG - Guided Missile Destroyer
FF - Frigate	FG - Guided Missile Frigate
*JJ - Skunk	*JJ - Unidentified or Enemy Surface Contact Detected by Radar
	*JB - Unidentified or Enemy **large** Surface Contact Detected by Radar
	*JM - Unidentified or Enemy **medium** Surface Contact Detected by Radar
	*JS - Unidentified or Enemy **small** Surface Contact Detected by Radar
	*JV - Unidentified large warship >500 ft
	*JW - Unidentified medium warship >300 ft
	*JX - Unidentified small warship <300 ft
LL - Amphibious Craft	LHA - Amphibious General Assault Ship
	LHP - Amphibious Assault Ship Helicopter
MM - Mine Warfare Vessel	
PP - Motor/Patrol Craft	PBF - Patrol Boat, Fast

Notes:

1. Unless stated otherwise, all designators above are assumed to refer to hostile or potentially hostile contacts.

2. * Denotes designators not included in STANAG 1166 (Edition 4).

Table8-3A1-4(C) - Selected Target Designators

SERIAL	TIME	EVENT	MESSAGE CONTENT
1	H to H+3	UHF Broadcast	Full SURPIC
2	H+3 to H+6	HF Broadcast	Full SURPIC
3	H+10 to H+11	UHF Broadcast	Abbreviated SURPIC
4	H+11 to H+12	HF Broadcast	Abbreviated SURPIC

Notes:

1. The Broadcast time "H" is to be the whole hour or 20-minute intervals from it.

2. Aircraft with simultaneous UHF/HF transmission capability should broadcast serials 1-4 on both frequencies.

3. Once beyond the Gate, attack aircraft should be given abbreviated reports every 10 track miles.

4. For deceptive purposes, abbreviated SURPIC and VASTAC should be made on a seperate frequency on a random basis.

5. As required, full or abbreviated SURPIC reports may be transmitted out of sequence.

Table 8-3A1-5(C) - SURPIC Broadcast Schedule

INTENTIONALLY BLANK

APPENDIX 2 TO ANNEX A TO
SECTION 8, CHAPTER 3 TO
TORNADO GR1 TACTICS MANUAL

ATTACK PROCEDURES

1.(C) **Introduction.** Attack procedures for the Tornado were originally developed for use by the Buccaneer/Nimrod MR2. In order to hold the attack aircraft on radar the attack aircraft is required to squawk MODE 2. However, the procedure could be used by any shadower capable of holding both the target and attacking aircraft, eg SKW, P3.

2.(C) **Tasking.** The tasking authority will notify the attack support aircraft, either by pre-flight or inflight message, of the requirement to conduct attack support. The tasking message is to include as many of the elements listed in Appendix 1 as are applicable to the task and the forces assigned.

3.(C) **TRU Action.** On receipt of the order to conduct attack support, the TRU is to take up position such that the target and the attack aircraft gate(s) are within radar range. If the aircraft cannot hold both areas, contact on the target is to be maintained while positioning to obtain the earliest possible detection on the inbound attack force. SURPIC broadcasts should be continued using the format and broadcast schedule at Appendix 1.

4.(C) **Attack Aircraft Action.** Attack aircraft will monitor the briefed UHF and HF SURPIC frequencies whilst in transit and update the gate position accordingly. Five minutes before gate arrival they should monitor the briefed VASTAC frequency and begin squawking IFF Mode 2. The Squawk is to be maintained unless otherwise ordered or until the attack aircraft are confident of their attack solution. At this point they should switch off their Mode 2 and the TRU returns to the random abbreviated reports.

5.(C) **IFF Procedures.** The IFF procedures provide a basic plot-lock between the TRU, the attack aircraft and the target. In the event of confusion the following codewords may be used to aid clarification of the situation:

a. **STRANGLE PARROT ONE.** STRANGLE PARROT ONE is transmitted by the TRU when garbling of the IFF occurs. Only the lead aircraft of each element should then squawk.

b. **STRANGLE PARROTS ALL.** STRANGLE PARROTS ALL is transmitted when the TRU requires all IFF to be selected to Standby. This is normally used by AEW aircraft once identification of the attack elements has occurred.

c. **BANDWAGON.** The codeword BANDWAGON may be used to indicate a change of control of IFF to another aircraft. For example, if the lead aircraft has not received a STANDBY MARK check, he should transmit BANDWAGON and deselect his Mode 2 whilst the second aircraft commences the squawk.

6.(C) **Approach to the Target.** Elements from the attack force are to proceed from their gate to their inbound attack axis as determined by the tasking message or any subsequent update in the SURPIC message. The TRU is not to change either of the parameters unless that alteration will significantly increase the probability of acquisition of the HVU by the missile(s) or if the ordered parameters would have presented an unacceptable risk to the attacking force (eg other enemy forces, extreme weather). Unless notified of a significant delay in arrival of one of the attack forces by the MHQ/OTC, the MTOT is to remain as ordered. If no IFF response is seen from the attack aircraft at the attack time, continue with the SURPIC and abbreviated SURPIC broadcast referenced to the Gate.

7.(C) **STANDBY/MARK Checks.** The abbreviated SURPIC message will be used to provide 'Marks' to the attacking aircraft. Following receipt of Mode 2 IFF, abbreviated SURPIC messages are transmitted by the TRU until IFF is strangled. A Table giving the procedures for participating units is at Table 8-3A2-1.

Ser	Action by Shadowing Aircraft	Action by Attacking Aircraft
1	Broadcast the SURPIC andVASTAC iaw Appx 1. Pass Marks using the COVEC bearing and range of the RP from the Gate.	Monitor Briefed UHF and HF frequencies
2	Fly suitable holding pattern. Select radar to most suitable scale. Interrogate all Mode 2 codes.	
3		5 min prior to Gate squawk Mode 2
4	If no IFF response seen from attack wave(s) at anticipated attack time continue with SURPIC and Abbreviated SURPIC broadcasts.	
5	When attack aircraft Mode 2 IFF observed pass VASTAC message at 10 nm intervals. Pass Marks using the COVEC bearing and range of the RP from the attack aircraft IFF. If the attack formation is seen to split for a 2-axis attack, alternate the marks between the two elements.	If a Mark is not received consider BANDWAGON procedures. If split axis tactic employed, be aware that the TRU will alternate the VASTAC messages between elements.
6	Maintain Abbreviated SURPIC, until attack aircraft Mode 2 is no longer seen.	Switch off Mode 2 when sufficient data has been received to conduct the attack
7	When IFF no longer seen revert to Abbreviated SURPIC, passing Marks using COVEC bearing and range of the RP from the Gate.	Carry out the attack

Table 8-3A2-1(C) - VASTAC Actions for Participating Units

APPENDIX 3 TO ANNEX A TO
SECTION 8, CHAPTER 3 TO
TORNADO GR1 TACTICS MANUAL

FORM TURQUOISE

1.(C) The FORM TURQUOISE is a tactical message used to task an ASUW mission and to authorise the launch of ASMs. It is addressed to the firing unit, TRU, and/or the Controlling Authority and information to adjacent and subordinate commanders and others who may be affected. FORM TURQUOISE format is at Table 8-3A3-1 and an example is at Table 8-3A3-2.

2.(R) Changes to an already issued FORM TURQUOISE should be made in accordance with APP-4.

3.(R) A TURQUOISE REQUEST is used by the commander to request an ASUW attack using assets from another command. The results of an ASUW mission are reported on FORM PURPLE. Examples of both are in EXTAC 322.

C	EXER/exercise name
C	OPER/operation identification
M	MSGID/TURQUOISE/message identification, originator, serial and date
	REF/reference
M	MISSNID/mission identification
M	TASK/task
	TARPOS/target position
	FORCE/force identification
	ACCS/aircraft callsign
	ORDN/ordnance
	ROUTE/routing and time
	HANDO/handover gates
	ALT/altitude
M	TIME SPEC/mission timeframe
	FYFCE/friendly forces
	FYPOS//friendly forces position(s)
M	COMMS/communications
	RVDU/rendezvous information
	CODES/codes, crypto and authentication
	EMCON/emission control plan
	IFF/SIF
	ISR/identification safety range
	TYCON/type of control
	ACAVL/aircraft availability
	RMKS/remarks

C: conditional fields
M: mandatory fields

Note: Fields "FORCE" to "TIME SPEC" will be repeated as necessary for each aircraft attack group.

Table 8-3A3-1(C) - Format of FORM TURQUOISE

O P 031000Z JUL XX

From: CTF 509 (COMMAIREASTLANT)
To: CTF 401 (Carrier Striking Force)
TG 509.4 (RAF KINLOSS)
TG 509.7 (RAF LOSSIEMOUTH)
TG 407.3 (NLTG)

NATO CONFIDENTIAL

EXER/SEAFIRE TWO//
MSGID/TURQUOISE/CTF509/003/JUL//
REF/AIR
INTENT/CTF509/021134Z1/JUL/XX/001/KIC//
MISSNID/08/CTF509/001///
TASK/ATTACK/6/DFOR85B/1/KIROV//
TARPOS/613ONO-01135WO/030715Z6/21OT/2OKTS//
FORCE/120SQDN/1/NIMROD/J9G///
ACCS/JULIETTE NINE GOLF/1-23/2-2467/3-1243//
ROUTE/031400Z8/5900N4-01000W1//
ALT/ONSTA/FL180//
TIME SPEC/SURV/031400Z8/032000Z5//
AMPN/ACT AS TRU FOR TORN - F/A-18 ATTACK PACKAGES. PROVIDE SURPIC
AS GIVEN IN EXTAC 322 SCHEDULE//
FORCE/12SQD/6/TORNADO/AJL/MISSN 301///
ACCS/ALFA JULIETTE LIMA/1-19/2-2351/3-1651//
ORDN/SEA EAGLE/2///
AMPN//
ROUTE/031430Z1/5700N2-01000W1/031445Z7/5700N2-01300W4//
ALT//
AMPN/MISSN ALT AT FLT LDR DISCRETION//
HANDO/GATE TWO/180T-120NM//
FORCE/CAG17/4/F-A18/MISSN121///
ACCS/JULIETTE MIKE GOLF/1-16/2-2325/3-1511//
ORDN/HARPOON/4///
ROUTE/031450Z3/6000N6-02000W2//
ALT//
AMPN/MISSN ALT AT FLT LDR DISCRETION//
HANDO/GATE ONE/270T-150NM//
AMPN/MISSILE TIME ON TARGET IS 031505Z4//
AMPN/COVEC VALUE IS 50//
FYFCE/TG407.3/12/NLTG//
FYPOS/TG407.3/5430N2-1840W3/030800Z1/030T-
18KTS/NL///
COMMS/SURPIC/JULIETTE NINE GOLF/4073KHZ/
P/139.8MHZ/S/128.3MHZ/T/VOICE../VASTAC/P/383.50/S/298.75/
CODES/AMSK1152/DAYO3/AMSA1601//
EMCON/BRAVO/031400Z8/032000Z5//
RMKS/VISUAL ATTACK ASSESSMENT NOT AUTHORISED//

Table 8-3A3-2(C) - Example of Form TURQUOISE

BREVITY CODEWORDS (ACP 165E)

ANGELS	Height of aircraft in thousands of feet.
AUTOCAT	Any communication relay using automatic retransmission.
BANDWAGON	Used during attack control direction to request attack aircraft to switch on/off IFF (SIF).
BENT	Equipment indicated is unserviceable. Cancelled by "Okay".
BLIND	When a contact which is expected to paint does not show.
BOGEY	Unidentified, presumed hostile track.
CEASE REPORTING	Cease reporting contact designated.
CHERUBS	Heights of aircraft in hundreds of feet.
CLUTTER	Permanent echoes, cloud or other atmospheric echo on radar scope, or contact has entered scope clutter.
COVEC	Range and bearing passed as coded vector.
ESTIMATE	Report target track and speed.
FADED	Contact has disappeared from radar.
FAMISHED	Have you any information or instructions?
FREELANCE	Positive and Advisory control not available.
HEADING	Target true course.
HEIGHT	Heights LO - targets is below 2,000 ft. HI - targets is above 25,000 ft.
HOSTILE	A contact positively identified as enemy.
INDICATING	Target speed in knots where: SLOW is less than 200 kn. FAST is in excess of 600 kn.
INTERROGATE	Check IFF return of designated contact.
LAZY	Equipment switched to standby.
MERGED	Tracks have come together.
MIDDLEMAN	RT relay capability.

ORBIT	Circle (No visible datum).
OVERRIDE	Positive Control.
PATROL	Systematic investigation along barrier line or zone to prevent an object from crossing undetected.
PENDING	A new track which on initiation cannot be given one of the other identities.
PINNACLE	An emission believed to originate from an assumed friend or friendly platform.
PLAYBOY	Airborne Tactical AIR CO-ORDINATOR.
PREVIEW	Advisory control.
RACKET	Intercepted electronic emission which is unidentified but assumed to be enemy and which has been assigned a serial number.
REPORT	Report contact designated at frequent intervals.
RONSON	Picture matching.
SCRUB	Erase contact designated.
SOUR	Equipment indicated is operating at reduced efficiency.
SPLITTING	Contact is dividing.
STRANGLE	Switch off equipment indicated.
STRANGER	An unidentified contact. Not associated with action in progress. (Bearing, range and altitude relative to you).
SWEET	Equipment indicated is operating efficiently.
WATCH	Continue sweep as directed and concentreate on contact designated. Do not report unless there is a material change in this contact.

CHAPTER 4 - SEA EAGLE TACTICS

TO BE ISSUED.

INTENTIONALLY BLANK

CHAPTER 5 - PAVEWAY TACTICS

To be Issued by Amendment

INTENTIONALLY BLANK

CHAPTER 6 - COUNTER AMPHIBIOUS LANDING OPERATIONS

1.(C) Tornados could be tasked against amphibious landings, particularly in Northern Norway; indeed the CIS Northern Fleet has been active in exercising amphibious operations in recent years. This Chapter briefly describes CIS amphibious operations and suggests general tactics against amphibious forces in transit and during the landing.

CIS AMPHIBIOUS CAPABILITY

2.(C) The CIS requires amphibious forces for the following reasons:

a. To provide an assault landing capability in support of operations conducted by the Ground Forces during war. This support would probably include, but is not limited to:

(1) Assaults against commanding islands and land areas in the vicinity of exits from the Baltic and Black Seas, thus permitting transit by CIS naval forces and denying access to hostile forces.

(2) Coastal assaults ahead of and in conjunction with land offensive or airborne landings behind enemy fronts in areas such as Northern Norway, the Baltic and Black Sea coastal regions.

b. To provide for coastal defence in key areas.

c. To conduct independent small scale landings and reconnaissance raids in areas of light resistance. Such areas may possibly include lightly defended islands of strategic importance.

d. To provide amphibious elements within naval groups that may be deployed overseas where the existence of such elements would contribute to the role of the local naval presence in support of CIS foreign policy.

3.(C) **Administrative Lift**. The CIS has the capability to lift large forces over extended distances using ships of the merchant fleet. This capability, known as administrative lift, would probably be used for follow-up Ground Forces in a major amphibious assault.

4.(S) **Concept of Amphibious Combat Operations**. In a major CIS amphibious operation the Soviet Naval Infantry (SNI) would have the mission of conducting spearhead amphibious assault and would secure the beachhead for the probable later arrival of Ground Forces follow-up units embarked in merchant ships. CIS amphibious operations would typically be conducted in three main phases; embarkation, transit and assault. Following, are some of the events which may occur during a major amphibious assault operation:

a. **Embarkation**. Troops and equipment are assembled at a waiting area, then move to embarkation points. Whenever practicable, embarkation is accomplished under cover of darkness; the landing force may embark from several locations to maintain secrecy. Vehicles and equipment are carefully loaded to permit a speedy disembarkation at the landing area. Merchant ship loading operations (for follow-up forces) would probably require port facilities.

b. **Transit**. Ideally, CIS amphibious forces conduct the transit during a single night with the attacking force in position by day-break, although this may not always be possible due to distance factors. Radio silence and darkened ships can be expected and the formations may be dispersed. The transiting force can include amphibious assault ships, merchant ships, mine sweepers and escorts. The escorting force may include submarines, together with surface ships ranging in size from gun-armed cruisers to missile-armed patrol craft. Protection from air, surface and subsurface attack would be provided by the escorts and by weapons fitted on the amphibious ships. Limited defence may be provided by the deck-loaded assault force weapons (such as ZSU-23-4 anti-aircraft guns and hand-held SAMs on merchant ship decks). Feints and other deceptive techniques may be used to disguise the actual objective. When the assault force approaches areas thought to be mined, the formation decreases speed and mine sweepers take up positions to sweep for influence and contact mines. Prior to reaching the "line of tactical deployment" (approximately 20 km offshore from the landing site) the transit group slows with all non-landing ships falling astern. By the time the assault landing group reaches the line of tactical deployment the commander of the assault landing force has selected his landing sites, formed the landing formation and dispatched the beach bombardment group to soften the landing area's defences.

c. **Preliminary Assault.** A major amphibious operation would often be accompanied by co-ordinated paradrops or land-based heliborne operations to the rear of the beach area; these airborne forces could disrupt enemy defences, prevent employment of enemy reinforcements and perhaps capture an airfield or port facilities to support the landing of additional forces. The naval gunfire support group bombards the beach from, typically, 8 km offshore. CIS Naval Air, if available, may provide close air support and other CIS air assets would strive for local air superiority. As mine sweepers conduct sweeps close to the beach, the landing force is formed into waves (typically three waves for a SNI landing) and screening units take up positions to protect against a seaward attack. The first element to reach the shore would typically be a small vehicle group including a PT-76 amphibious tank and BRDM-2 amphibious scout cars. This small element is tasked with establishing communications ashore and co-ordinating the air and sea bombardment of the landing area defences. Closely following this spearhead element may be a detachment of assault engineers to continue preparing the landing sites for the main assault force.

5.(S) **Main Assault.** The main Naval Infantry assault is conducted by PT-76 amphibious tanks and armoured personnel carriers which approach the beach from vessels offshore. If the degree of enemy resistance and the bottom topography permit, the initial waves may be landed directly onto the shore by beached amphibious ships. A Battalion Landing Team is typically assigned three landing points covering a total distance of about 1 km. Each point is assaulted by a group consisting of about three tanks and twelve armoured personnel carriers; the amphibious assault vehicles may fire their weapons whilst en-route to the beach. Once on the beach, the tanks move forward to establish a perimeter around the beachhead and the assault troops remain in the armoured personnel carriers until enemy resistance is met. Upon encountering resistance, the troops dismount from their vehicles which then provide supporting fire. The final elements of Naval Infantry to come ashore are not embarked in amphibious armoured vehicles but landed directly on the shore from beached amphibious ships or ferried ashore in amphibious transporters. These elements include the ZSU-23-4s, the BM-21 rocket launchers, the logistic vehicles and wheeled weapons. During the assault a high rate of disembarkation can be expected with precise co-ordination among ships, aircraft and the landing force. ECM support may be provided by CIS ships and aircraft; smoke-screens may be used. When the beachhead and immediate tactical objectives are reasonably secure the Ground Forces follow-up troops land and carry the battle inland. These elements disembark from their merchant transport ships through captured port facilities or by using small landing craft deck-loaded on the merchant ships. Naval amphibious vessels which have already disembarked their Naval Infantry combat loads may also be used to transport the follow-up forces from the merchant ships to the beach. Seized port facilities may be used to unload Ground Forces elements from RO-RO ships, however Ground Forces amphibious-capable vehicles (such as PT-76 tanks and armoured personnel carriers) may drive off the RO-RO ramps into the water and thence to the beach, or equipment may be unloaded directly from barge carriers. If time permits, pontoon causeways may be constructed to the beach. The SNI forces which led the assault may remain as security forces or may be re-embarked for further assault operations. Air support will probably be an integral component of any opposed amphibious landing. CIS aircraft are capable of providing pre-assault reconnaissance, air-superiority operations, bombardment and electronic warfare operations. Use of any of these capabilities will be dependent upon the threat and upon the availability of aircraft.

NATURE OF THE PROBLEM

6.(R) The purpose of an amphibious landing is to deliver a concentrated force of overwhelming strength at a point and then rapidly deploy and consolidate. It follows, therefore, that the aim of the defensive air forces should be to prevent the concentration taking place on land.

7.(C) An amphibious force can be expected to contain organic defence against sub-surface, surface and air attack. The assault and transport vessels are vulnerable to attack from all three and need escorts. The escort forces will operate in all three environments and will be deployed to protect the assault convoy. It can be assumed that any or all frontline SA-N or AAA systems will be employed, augmented by air defence aircraft and AEW.

8.(S) Since the purpose of the fleet is to land the ground forces concentrated on board the transport and assault craft, it is better to sink concentrations of material and personnel within their ships rather than attacking after they have landed. The drawback is that the naval perimeter defences on the high seas will be very difficult to penetrate. On the other hand, attacking a concentrated, prepared land force after it has consolidated could be even more hazardous.

9.(S) The best time for an attack will be in the transitional period between the deep-sea transit and the assault. During this period the Naval Defences will be limited by confined waters and degradation of Early Warning due to land returns. Therefore they will have difficulty providing all round protection while the disposition of the fleet is changing. As the assault starts there will be a bombardment of the landing area, probably from sea and air while the deep sea escort stands off to seaward to protect the "back door". The vertical nature of the Norwegian terrain and the confined aspect of some fjords may allow an air attack to be planned from the land thereby reducing exposure time to defences. The drawback is that there may be little opportunity to plan and co-ordinate an attack if made from masking terrain.

10.(S) In areas where terrain is less vertical, the principle previously expounded will still have advantages although the separation distances between naval escort and the assault vessels may be less; the terrain screening and restrictions on major naval unit movement will be reduced, but shallow water may restrict their freedom of action.

11.(S-UKB) Sea Eagle attacks during the amphibious force transit could either be targeted against the escort vessels or be attrition attacks against the whole force. The first case would require a TRU capable of target classification and VASTAC, and would be a SEAD mission for a follow-up attack on the troop carriers, perhaps by less capable attack platforms. The latter case could result in an uneven distribution of hits on the smaller vessels although the ECM capabilities of the escorts should bias the missile targeting onto them.

SUGGESTIONS FOR OPERATIONAL PLANNING

12.(S) The success of any anti-amphibious operations will depend upon careful preparation. However, unless the tasking is timely, preparation will be wasted as the attacks cannot be delivered at the optimum time. Due to a combination of all the factors discussed above, there appears to merit in solving some of the problems along the following general lines (pre-planned in peacetime):

a. Examination and careful reconnaissance of likely landing areas.

b. Pre-planning of routes from refuelling/re-arming bases or coast-in points to each selected area.

c. Careful selection of possible approach routes and pre-IPs in the chosen areas.

d. Probing the sea approaches to the landing beaches to determine when the escort may be masked by narrow waters in an approach fjord.

13.(S) The pre-planning work will pay dividends for execution in wartime. There are some thorny tactical problems which will remain and they are summarised in "*Where are they and what is their disposition?*". A tactic which immediately suggests itself is the armed recce/probe concept which can resolve the 'where' problem; the disposition will be more difficult to discover in detail. Whilst it would be advantageous to have the attack force already airborne and thus minimise the delay between detection and attack, this may not be possible due to constraints of tasking, planning, fuel, weapon and map carrying capacity. It may therefore be necessary to reconnoitre, plan, update with probe and then attack, having narrowed down the target area. Hopefully it may then be possible to plan an attack at the most advantageous point in the assault forces route to the landing area.

14.(U) Sea Eagle attacks:

To be issued

15.(S) If a bomb attack is planned then the target designation problems are similar to those for Sea Eagle. LGB attacks may have to be carried out using one bomber and one TIALD elements. If unguided bombs are used then a dive attack may be the only viable option. With CBU, a dive attack has the further advantage that it produces a denser bomblet pattern than a level attack. The aiming points discussed below are equally appropriate to guided or unguided bombs.

16.(S) Detailed planning will have to be undertaken by the squadron both in time of peace and war in association with the tasking authorities of the nations concerned. The planning must consider the air threat, especially during the transit to the target area and very concentrated surfair defences in the target area; therefore deceptive routeing, maximum use of terrain screening and good planning to achieve swift, effective attacks will be vital.

ASSAULT CRAFT - VULNERABLE AREAS

17.(S) The majority of vessels used by the CIS Forces for amphibious assault and later re-supply have a common characteristic, eg the machinery and areas of greatest vertical extent are at or near the stern. The vessels used can be sub-divided between those which are built to take the ground on the assault beaches and those which stand off and/or use port facilities. The former vessels all have strengthened bows and undersides with, in the case of Tank Landing Ships, strengthened main load carrying decks, and the stand-off vessels have stressed load carrying decks only.

18.(S) Vessels which engage in an assault are all armed and will also be escorted by warships whilst in transit; these warships are comprehensively armed. The smaller vessels are all very vulnerable to a 1000 lb HEMC hit and there is a very real chance of disabling the larger vessels with the same weapon. It is pertinent to point out that deep water escort ships will be comparatively inhibited and may stand off during the landing period and there will be less room for manoeuvre in shallow water; the shallow water will lessen the effect of a miss but will enhance the effect of a bomb under or very close to the ship.

19.(S) For all ships with rear machinery it is reasonable to aim at the rear quarter of the vessel, this is intended to produce the following effect:

a. **ROPUCHA.** A hit at the base of the funnels should disable the machinery and possibly knock out the aft twin 57 mm and render the stern ramp inaccessible or inoperable. It is unlikely to sink the vessel or knock out all the embarked assault forces.

b. **ALLIGATOR.** A hit on the chosen point should produce a similar effect to that on ROPUCHA.

c. **POLNOCNY.** A hit on POLNOCNY will have a similar effect as that on ROPUCHA or ALLIGATOR but with the possibility that the ship could sink eventually.

d. **MP4.** There is a real chance of sinking an MP4 class LSM.

e. **ROFLOW/RO-RO.** The CIS Ro-flow/RO-RO vessels are unarmed, and can be as large as 25,000 tons; they could be sunk by a single hit or rendered either incapable of discharging their contents or immobile by a hit at the stern ramp or base of the funnels respectively. The Herald of Free Enterprise capsize illustrates the lethal effect of 'free flood' water in the holds of RO-RO vessels.

20.(S) Laser designation points for these vessels should be the centre of the visible superstructure. The larger RO-Flow and RO-RO vessels have sufficient freeboard to permit designation along the full length of the hull, notwithstanding the requirements to disable the ship first.

INTENTIONALLY BLANK

CHAPTER 7 - MARITIME RECONNAISSANCE

INTRODUCTION

1.(R) Tornados may be tasked to carry out reconnaissance of ships or groups of ships. The tasks could vary from peacetime intelligence gathering missions to wartime armed reconnaissance or post-attack reconnaissance missions. The tactics employed vary considerably between peacetime and wartime and will be considered separately in this Chapter.

AVAILABLE SENSORS

2.(R) **Visual.** The amount of information that can be gathered by the human eye depends mainly on visibility and the distance from the aircraft to the target; trials have shown that the use of hand-held magnifying devices at low-level is not feasible in tactical aircraft. In peacetime the crew should fly 1/2 nm abeam the target at 500 feet and 360 kn and attempt to note any differences between the target and a standard ship of its class, ship markings, movement of aerial or weapon systems, and any other signs of activity; a separate pass should be made on each side of the target. In wartime visual reconnaissance will be limited, at best, to providing identification and indication of major damage.

3.(R) **Cameras.** Maritime Tornado squadrons will be equipped with hand-held Pentax SP 100 cameras with f2 55 mm lens. Several passes should be made 1/2 nm abeam the target at 500 feet and 360 knots, and the navigator should take a number of pictures on each pass; this is necessary as the aircrew protective helmet precludes accurate aiming of the camera and some shots may be wasted. The camera is not suitable for use in wartime as it is impossible to aim it sufficiently accurately when equipped with the tele-photo lens which would be required to achieve a reasonably safe stand-off distance. The TIALD system can be used to provide videotape recordings of ship targets. TIALD is the preferred system in peace and wartime as it is inherently more flexible to operate and the image magnification in narrow FOV permits considerable stand-off ranges. In wartime all TIALD/Pave Way attacks should be recorded as the tapes might provide intelligence information in addition to a record of the attack.

4.(R) **Electronic.** The Tornado Cockpit Voice Recorder (CVR) can be used to record the aural information output from the RHWR, as well as any crew comments about the target. The TIALD video tape also records RHWR audio with a much better quality than the CVR. The resultant recordings provide information on the PRF and ARP of radars illuminating the aircraft and serves as a useful training or briefing aid for other crews.

PEACETIME TACTICS

5.(C) Peacetime reconnaissance missions may be tasked primarily to assist MPA shadowing aircraft to maintain an accurate surface plot of potentially hostile naval forces, but every opportunity should be taken to gather intelligence on these missions in addition to dedicated intelligence gathering sorties. In the past, the East European ships took considerable trouble to conceal new equipment and avoid electronic emissions when NATO aircraft were in their vicinity, so Tornados should attempt to surprise target ships by making a covert approach below the radar horizon while maintaining electronic silence. If the target maintains electronic silence the chances of a surprise reconnaissance pass decrease significantly as the GMR may have to be used to acquire the target. Once the target has been acquired, reconnaissance passes should be made using the sensor equipment available as described in paragraphs 2-4 above. Obviously, daylight and VMC are required for visual reconnaissance but electronic reconnaissance and TIALD could be used at night or in IMC.

WARTIME TACTICS

6.(R) Maritime reconnaissance missions in wartime are likely to be tasked as pre-attack probes, armed reconnaissance, or post-attack reconnaissance. Any task requiring visual information is likely to put the reconnaissance aircraft at some risk, particularly if visibility is poor and the aircraft has to enter AAA engagement zones to obtain information. The aircraft can avoid penetration of some SA-N engagement zones by remaining at 100 feet or below, and when visibility exceeds 4 nm TIALD video can be obtained without entering any of the target's AAA defence engagement zones.

7.(R) **Probe Tactics.** Probe tactics are described in Chapter 3.

8.(R) **Armed Reconnaissance Tactics.** It would not be normal practice to task maritime Tornados on 'seek and destroy' armed reconnaissance missions; attack Tornados are launched only when Attack Support is available to direct them towards a known target. There may be occasions when commanders authorise armed reconnaissance, particularly when the target area environment is considered unacceptably hostile for visual reconnaissance.

9.(C) **Post-Attack Reconnaissance and Tactics.** A commander always needs to know the results of an attack. Whilst individual aircraft may have some idea of their attack's effectiveness it may be some time before overall effects are apparent; in particular fires may not develop immediately and secondary explosions can occur some time after an attack. Formation leaders may be tasked to carry out post-attack reconnaissance, fuel permitting, as this may obviate the need to task a dedicated sortie. Target defences may still be active and the crew should adopt the probe tactics described in Chapter 3 when attempting visual reconnaissance.

Section 9

Medium Level and LGB Procedures

Chapter 1 Medium Level "Dumb" Bombing

2 Medium Level LGB Procedures

3 TIALD - SOPs and Tactics

4 Laser Target Designator / Remote Tone Generator - Procedures and Tactics

SECTION 9 - TABLE OF CONTENTS

CHAPTER 1 - MEDIUM LEVEL 'DUMB' BOMBING

Page Number
(within the Chapter)

INTRODUCTION 1

LEVEL ATTACKS 1
  Height Sensor Information 1

DIVE ATTACKS 1

MAIN COMPUTER BALLISTICS 2

THE HEIGHT CHANNEL 2

RADAR BOMBING TECHNIQUE 2
    Spoil Beam 2
    Pencil Beam 2
    Long/Short Pulse 3
    Range Scale and Scan Width 3
    MRI and Scan-to-Scan 3
    B-Scan 3
    Effect of System Height on Picture Stabilization 3

RADAR HANDLING TECHNIQUES 3
  Offset and Fixing Considerations. 3
    Selection 3
      Offset No 1 3
      Offset No 2 3
      Offset No 3 4
    Mensuration 4
    Identification 4
    Pre-bomb Fix 4

MAP ACCURACY 4
  Co-ordinate Transformation 5

SAFETY CONSIDERATIONS 5

ANNEXES

A: - DIVE ENTRY TECHNIQUE

Straight-in Approach A1
  Run-in A1
  At Tip-in Point A1
  Pre-Release A1
  After Release A1
  Warning A2
Offset Approach A2
  Run-in A2
  Pre-Release A2
  After Release A2
  Warning A3
Low Level Ingress - Pop-up Attack ('Hornet Pop') A3

- Run-in A3
- Pop-up Point A3
- Pre-Release A4
- After Release A4
- Warning A4

B: - HEIGHT CHANNEL CORRECTION

- ICAO Standard Atmosphere B1
- D-Value Correction B1
- Pressure Error Correction B1
- Height Channel Correction Procedure B1

CHAPTER 2 - MEDIUM LEVEL LGB PROCEDURES

INTRODUCTION 1

ACQUISITION PROCEDURES 1
- Locating the Target 1
  - Target Size 1
  - Weather 1
  - Smoke 1
  - Aircraft Altitude 1

LASING 1
- Lasing Period 1
- Target Obscuration 2
- Laser Detection Range 2
- Laser Codes 2

LGB DELIVERIES 2
- Bomb Release 2
- Seeker Field Of View 2
- Bombing Envelopes 2
- Gravity and Wind Effects 3
- Bomb TOF 3

LESSONS LEARNT FROM THE GULF 3
- Release Parameters 3
- Tactics and Planning 3

DETAILED PROCEDURES AND TACTICS FOR PAVESPIKE AND TIALD 4

ANNEXES

A: LGB RELEASE ENVELOPES

- Performance of Paveway 2 at 400kn Groundspeed - Table 9-2A-1 .... A1
- Performance of Paveway 2 at 450kn Groundspeed - Table 9-2A-2 .... A2
- Performance of Paveway 2 at 500kn Groundspeed - Table 9-2A-3 .... A3
- Performance of Paveway 2 at 550kn Groundspeed - Table 8-2A-4 .... A4

B: ~~TORNADO/BUCCANEER MEDIUM LEVEL LGB TACTICS DEVELOPED DURING THE GULF CONFLICT~~

A/L 2 (MS)

~~INTRODUCTION .... B1~~
~~The "Kindergarden" Tactic. .... B1~~
~~The 'O Level' Tactics .... B1~~
~~A' and 'S' Level Tactics .... B1~~

~~APPENDICES~~

~~B1: LGB Tornado Level Attack from 20,000ft - Auto Release .... B1-1~~
~~B2: Tornado/Buccaneer Pavespike SOPs - Kindergarten Level .... B2-1/2~~
~~B3: Tornado/Buccaneer Pavespike SOPs - 11+ Version .... B3-1~~
~~B4: Tornado/Buccaneer Pavespike - 'O' Level Tactics .... B4-1~~
~~B5: Tornado/Buccaneer Pavespike - 'A' and 'S' Level Tactics .... B5-1/2~~

CHAPTER 3 - TIALD - SOPS AND TACTICS

INTRODUCTION 1

SELF-DESIGNATION OF TARGETS AND FIXING BY TIALD 1
Passive Ph 4 1
Active Ph 4 1
Advantages of Ph 4 1

PLANNING PROCEDURES 2
Target Orientation 2
Target Obscuration 2
Wind 2
Sun Position. 2
Thermal Cross-Over 2
Target Area Defences 2
Route Planning 2

AIRBORNE PROCEDURES 3
Sutto 3
En-Route 3
Target Area - General 3
Target Area - Nav Actions. 3
Method 1 (Preferred Method) 4
Method 2 (Only to be used if the Slave is excellent) 4
Target Area Pilot Actions 5

ATTACK PROFILES 5
Profile 1 - One or Two DMPIs 5
Profile 2 - Medium-Level, Single DMPI 5
Profile 3 - Low Loft, Single DMPI 5
Profile 4 - 3 Separate Discreet DMPIs (TIALD Aircraft Bombing) 6
Profile 5 - One Large Complex with 3 DMPIs (TIALD Aircraft Bombing) 6
TIALD/Bomb Masking. 6
Timing 6
TOO LGB 6
LTM for CBU87 Attack 6
Target Study 6
Routine SOP RT Calls 7
Addition to Radio SOPs 7

AL 2(MS)

TIALD Loser Plan (TIALD Aircraft Not Bombing) 7
RTB 8

EXECUTION PROBLEMS 8
Timing Problems 8
Cloud 8
Bomber Kit Problems 8
Designator Kit Problems 8

TIALD HANDLING 9

ANNEXES

A: TIALD -LATERAL FOV v RANGE

Graph A1

B: ATTACK PROFILES

Profile 1 - 2 DMPIs - Figure 9-3B-1 .... B1
Profile 2 - Med Level Single DMPI - Figure 9-3B-2 .... B1
Profile 3 - Low Loft Single DMPI - Figure 9-3B-3 .... B2

C: LGB - MEDIUM LEVEL PROFILE IN REDUCED CLOUDBASE

Profile - Good IR Visibility Under Cloud - Figure 9-3C-1 .... C1
Profile - Poor IR Visibility Under Cloud - Figure 9-3C-2 .... C1

D: BACK-UP LGB RELEASE DATA

LGB Medium Level Release Data- Table 9-3D-1 .... D1
Alternative Method of Calculating Release Data
Method 1 - Basic Empirical Equation D2
Method 2 - Correction Factor Application D2
LGB Envelope at 400kn Groundspeed- Figure 9-3D-1 .... D3
LGB Envelope at 450kn Groundspeed- Figure 9-3D-2 .... D3
LGB Envelope at 500kn Groundspeed- Figure 9-3D-3 .... D4
LGB Envelope at 550kn Groundspeed- Figure 9-3D-4 .... D4

CHAPTER 4 - LASER TARGET DESIGNATOR / REMOTE TONE GENERATOR - PROCEDURES AND TACTICS

INTRODUCTION 1

THE RTG 1

LASER PRF 1

OPERATIONAL EMPLOYMENT 1

PLANNING 1

EXECUTION 2
Initial Checks 2
Loft Profile 2
Mini-loft Profiles 2

MULTI-SHIP/ MULTIPLE DMPIs 2
Pair/Single DMPI 3
Pair/Split DMPIs 3

- Pair and Different DMPIs 3
- Timing 3
- RTG Failure 3

COMMON PROBLEMS 3

MEDIUM LEVEL OPERATIONS 4

- Received Laser Energy 4
- RTG Timing 4

SUMMARY 5

ANNEX A: - LASER DESIGNATOR TASKING SHEET A1

INTENTIONALLY BLANK

CHAPTER 1 - MEDIUM LEVEL 'DUMB' BOMBING

INTRODUCTION

1.(C) During Operation GRANBY, Tornado GR1 operations were expanded to include high altitude bombing. As there was little practical information available to which crews could refer, CTTO was tasked to investigate the best methods of carrying out operational 'dumb' bombing from medium level. In the aftermath of the conflict, and having analysed results of the bombing, it is fair to question whether, in the future, a campaign of 'dumb' medium level bombing would be worthwhile. However, the war reinforced the lesson that we must be prepared to carry out whatever mission is required and the lessons of 'dumb' bombing should not be forgotten. This Chapter is a precis of the best advice available on 'dumb' medium level bombing; it relies heavily on the results of CTTO Trial COBNUT which evaluated Tornado medium altitude level and dive bombing with freefall 1,000 lb bombs.

LEVEL ATTACKS

2.(C) Level attacks are best flown at around 20,000 ft altitude and approximately 450 KTAS/0.75 TMN on a predetermined line of attack (LOA). The auto-pilot should be engaged prior to weapon release to facilitate steering to the release point since the HUD weapon aiming display enters memory mode before the weapon release point. Alternatively, the attack may be flown manually following flight director steering commands.

3.(C) **Height Sensor Information.** Phase 1 laser ranging is precluded by the LRMTS gimbal and maximum slant range limits, and the rad alt becomes inoperative above 5,000 ft AGL. GMR lock-on and GMR height find modes are ruled out because they are operationally impractical. Also, if the GMR lock-on mode is used, the weapons release point is close to the GMR antenna tilt limits and loss of lock-on could possibly occur at a critical point in the attack. BARO/IN is the only available height sensor.

DIVE ATTACKS

4.(C) Three possible dive entry techniques are available for dive attacks: over-banking into the dive from an offset run-in approach, a direct approach to target on LOA before rolling inverted and pulling the VV down to the target, and a direct approach with a bunt entry into the dive. However, the bunt entry technique is not considered practicable for steep dive attacks since it takes over 30 sec to achieve line-of-sight to the target and as this point is almost coincident with weapon release, there is little or no time to refine the radar mark. Details of dive techniques are at Annex A.

5.(C) Release parameters are a compromise between minimising attrition and achieving satisfactory weapon accuracy. Point defence SAMs and AAA are best avoided by remaining above 15,000 ft, whereas steep dive attacks weapon accuracies increase as release height is reduced. Thus the optimum run-in height to reduce exposure to short range target defences is 25,000 ft at M0.7. In a 45° dive, release will occur by 15,000 ft at a speed of around M0.85-M0.89. With airbrakes out, the recovery is limited to 14 alpha or 4g and height loss will be in the region of 4,000 ft.

6.(C) Crews should be aware that with the long slant ranges involved in a dive attack from medium level, visual target acquisition could be extremely difficult in other than ideal conditions. With a small target (in relation to the HUD symbology) and the long stand-off release ranges, accurate target marking may be difficult to achieve.

MAIN COMPUTER BALLISTICS

7.(C) For freefall weapons, two sets of ballistics are used in the MC. Below 10,000 ft ATL the MC uses 'dive' ballistics regardless of aircraft dive angle, whilst above 10,000 ft ATL 'medium level' ballistics are used. If the aircraft transitions between the two ballistic height zones during the course of an attack, automatic weapon release can be inhibited for 0.1 sec until the ballistics re-stabilise using the algorithms for the new height zone. The ballistic change-over is discernible in the HUD as a jump in the CCIP position. As the change-over zone extends 100 ft either side of the 10,000 ft ATL boundary, it is important for crews not to release weapons within this height band.

THE HEIGHT CHANNEL

8.(C) Updating the BARO/IN height channel overhead the target by a rad alt height fix at attack IAS is one way of updating the height channel but, unfortunately, not a valid operational technique. However, it could be modified for operations by height fixing below 5,000 ft AGL in the climb to altitude and then applying a correction based on target area QNH. This method is based on the technique evolved from Trial TRADAR. However, impact errors are typically around 1,000 ft in the undershoot.

9.(C) Although the GMR would provide an accurate slant range for medium level bombing, any BARO/IN height error would cause the MC to calculate an incorrect plan range to target and an incorrect forward throw. For Phase 1 attacks, the plan range and forward throw errors would be in the same sense and therefore cumulative in terms of miss distance. For Phase 2 and 3 dive attacks, the errors would be in the opposite sense and would tend to cancel each other. In the case of Phase 1 attacks, the cumulative effect of any system height error would be an impact error in excess of 100 ft for every 100 ft of height error.

10.(C) Two methods for setting up the BARO/IN height channel are available: the TRADAR corrected rad alt update method, and the application of forecast D-values to the HUD baro pressure altitude reading using a HUD baro sub-scale setting of 1013 mb. The TRADAR method, normally used for low level bombing, gives inaccurate and inconsistent results at medium altitudes. In contrast, correcting the MC system height by referencing to ICAO pressure altitude and then employing D-value pressure altitude corrections gives more consistantly accurate results. A comparison of the refined MC system height with the true height of the aircraft has found a close correlation within ±60 ft. Further information on the subject of D-values and their application is shown in more detail at Annex B.

11.(C) The reliability of GPS readings in suitably equipped aircraft suffers because the GPS receiver was installed as a stand-alone system and not integrated with the aircraft avionics. Following any manoeuvre, such as a level 180° turn, it can take 2-3 minutes for the GPS constellation to be re-acquired and for an accurate 3 dimensional lock to be achieved. However, the GPS has potential as a source of accurate height.

RADAR BOMBING TECHNIQUE

12.(C) Experience gained during SAC Bombing Competitions, the Gulf conflict and Trial COBNUT has resulted in the following lessons:

a. **Spoil Beam.** In terms of picture quality, spoil beam is unusable for fixing and attacks. It suffers from low reflected energy because the radiated power is spread throughout a deep "$cosec^2$" beam. Lack of uniformity in the power radiation within the vertical lobe causes severe banding effects on the CRPMD.

b. **Pencil Beam.** In pencil beam, a narrow band of video appears across the screen which is very sensitive to tilt control adjustments. If no discernible returns appear in the larger scale range settings, it is advisable to re-select a smaller scale picture (eg 40 nm scale), select a wide scan and adjust the tilt thumbwheel until the video band is superimposed over the fixing cross.

c. **Long/Short Pulse.** Long pulse is recommended until a usable picture became available at closer ranges with short pulse. The auto PRF change at 20 nm necessitates re-adjustment of the MRCP controls to maintain a clear display at the point of interest.

d. **Range Scale and Scan Width.** Once the target or offset is positively identified, the range scale can be reduced as the range reduces. Narrow scan and fast scan are recommended to obtain the maximum refresh rate for the picture.

e. **MRI and Scan-to-Scan.** For suitably discrete responses, MRI is recommended with long or short pulse selected as appropriate to obtain a good radar response. To stabilise the MRI spot, the scan-to-scan facility should be selected.

f. **B-Scan.** Use of B-scan improves azimuth discrimination at short range.

g. **Effect of System Height on Picture Stabilization.** An error in the MC system height results in inaccurate slant to plan range conversion and becomes apparent as poor picture stabilization. This necessitates frequent re-positioning of the aiming cross over the radar response.

RADAR HANDLING TECHNIQUES

13.(C) Of particular significance to a successful Phase 1 attack is the importance of an accurate nav system and the careful selection and use of offset aiming points (OAPs). The requirement for OAPs to be within 20 nm of the target is restrictive but can be overcome, at the expense of a small increase in cockpit workload, by using a pre-bomb-run fixpoint. Preferably this should be carried out in a low threat area as close to the target as possible.

14.(C) **Offset and Fixing Considerations.** If the target is likely to be either a very late show response or non-discrete, an accurate navigation system position and judicious selection and employment of OAPs is essential to the success of radar bombing. The following aspects need to be considered:

a. **Selection.** OAPs require careful selection. Different selection criteria should be used for each of the three offsets as follows:

(1) **Offset No 1.** A large unambiguous feature should be chosen as the first offset and should be easily identifiable in case large system errors are present in the navigation system. Line and significant features in the vicinity of OAP 1, such as coastlines, wide rivers, major roads/ railways and towns, industrial areas, lakes, large dams and long bridges could help to resolve ambiguities in identification if navigation system performance was degraded.

(2) **Offset No 2.** Ideally OAP 2 would be a smaller isolated response compared with the lead-in offset to allow significant refinement of the CRPMD mark. The response should be sufficiently discrete to permit final weapon aiming if necessary.

(3) **Offset No 3**. OAP 3 should be selected close to the target and preferably up to 4 nm in the target overshoot. However, it could be laterally offset either side of the target in the overshoot area, provided it remained within the limits of the radar scan during the final stages of the attack. Aiming refinement would therefore be available right up to the point of weapon release. The final aiming offset should be chosen to provide a small discrete response and invariably would be a small man-made feature such as an isolated small building, a single oil or water tank, a metal grain storage bin or the intersection of 2 line features. Unlike at low level, the steeper grazing angles obtained at medium and high altitude mean that wood features merge into, or could be swamped by, the returns from ground clutter. Finally, the offset could be so small that it might only be seen for the last few seconds of the bomb-run. Therefore the first 2 offsets play an important part in the attack sequence.

b. **Mensuration**. Accurate mensuration in all 3 dimensions from vertical imagery or 1:25,000 and/or 1:10,000 scale maps is essential. The commonly used 1:50,000 scale maps are too inaccurate for reliable results. Comparing reconnaissance imagery with the same features portrayed on large scale maps allows the precise radar significant features within a group to be identified for subsequent mensuration. This is particularly so for cultural features where the radar centroid might be different from the visual centroid of the symbols representing the same group on a large scale map. At medium and high level, cultural features tend to be the most radar significant features and lack of vertical extent is not so critical. It is important when measuring fixpoint, OAP or target positions that all positional information is converted to the same map datum before preparing the mission data tape. If a common position datum is not used, large discrepancies could occur in offset measurements and when commencing fixing or attack routines, the position of the CRPMD marker would not necessarily be close to the intended response. This would increase the risk of mis-identification and designation of an incorrect aiming point.

c. **Identification**. Correct identification and precise marking of OAPs and targets by the operator is essential for a successful radar attack. The identification process is aided by study of radar predictions of the target and OAPs. Where accurate radar predictions are not available, a thorough study of the large scale map and available imagery for the bomb-run is necessary.

d. **Pre-bomb Fix**. Up-dating the navigation system with an accurate fix before commencing the bomb run increases the chance of successful OAP and target acquisition. Where similar radar responses are in proximity to one another, an accurate fix would also reduce the risk of offset or aiming point mis-identification.

MAP ACCURACY

15.(C) Accurate mensuration of DMPIs and OAPs is essential if a non-discrete target is to be hit. Currently, the most accurate positional information can be obtained from Zeiss Point Positioning System (PPS) equipment which is located at JARIC and on main operating bases. The PPS equipment uses classified satellite imagery and requires a skilled operator. As the process is relatively labour intensive, it is employed only for pre-planned targetting and strike mission planning. Unfortunately, 1:50,000 scale maps do not represent the real world with sufficient fidelity or permit sufficiently accurate extraction of positional data for consistently accurate radar bombing, particularly when using an offset aiming point at weapon release. To achieve accurate and consistent results, it is recommended that PPS equipment in association with vertical imagery or the use of 1:25,000 or 1:10,000 scale maps is required.

16.(C) **Co-ordinate Transformation.** It is important that all positional information is based on the same map datum and earth model. Gross errors can occur if an accurate pre-bomb-run fix is based on one map datum and the OAPs and DMPIs for the target have been mensurated using another. At best, a large correction will be required to slew the CRPMD marker to the correct response and at worst, large discrepancies could lead to a failure to identify the correct feature on radar. The mathematical algorithms to convert positions from one datum to another are relatively straightforward and can be performed easily by desk top computers.

SAFETY CONSIDERATIONS

17.(C) It is imperative that, prior to any medium level bombing mission, certain safety considerations are noted and acted upon. Firstly, the arming time on the weapon must be set to the maximum possible delay commensurate with the bomb time-of-flight. Secondly, even if the arming time has been set to the maximum, it may still be necessary to carry out an escape ~~evasive~~ manoeuvre immediately after the bombs have been released to ensure the aircraft is out of the fragmentation envelope should the bomb detonate at the arming time.

AL2 (MO)

INTENTIONALLY BLANK

ANNEX A TO
SECTION 9 CHAPTER 1
TORNADO GR1 TACTICS MANUAL

DIVE ENTRY TECHNIQUE

1.(S) **Straight-in Approach**

Run-in

Wings	25° WS Cruise - M0.70 - M0.75 45° WS Cruise - >M0.75

At Tip-in Point	*0 sec TTG for 45° Dive* *6nm DTG for 30° Dive @ 20,000ft Run-in alt* *7.5nm DTG for 30° Dive @ 25,000ft Run-in alt*

Wings	45° WS (Mnvrs A/R)
GMR	Deselect Stab or Select M+S
Throttles	Idle Idle

Roll inverted pull nose down to HUD tgt bars then rapid roll to erect flight and track BFL through target.

Airbrakes	Out
PHC	Phase change Align tgt bar with tgt

If AGR required

CRPMD/PHC	Select AGR
NWAMS	RDR ACPT SEL lit

If Laser ranging required

LRMTS	LIVE, target range <4.3nm (and inside FLFP)

Pre-Release

Late Arm	Live
WRB/ARB	Press and hold for release

After Release

WCP1 and 2	Check for release deficiencies
Late arm	Safe
LRMTS	INHIBIT/ STBY

Notes

1. Carry out initial roll-in manoeuvre into wind to minimise BFL/HUD Tgt Bar tracking problems.

2. Aligning final LOA into wind will reduce tracking difficulty.

3. Place VV symbol approx 2° above the target in the dive.

4. Max 14 AOA in recovery with airbrakes out.

5. Employ dive/toss technique if necessary to achieve release by desired recovery altitude. keep flight path below 10 degrees nose-up until weapon release.

6. Errors obtained from Phase 3 target marking may be unreliable.

7. Do not move mark during pull-out (mark drifts long).

WARNING

> With MASS and Late Arm live, it is possible to release weapons in inverted flight if the WRB/ARB is inadvertantly pressed during the tip-in manoeuvre.

2.(S) **Offset Approach**

Run-in

Wings	25° WS Cruise - M0.70 - M0.75 45° WS Cruise - >M0.75

At Tip-in Point *(Apex point is approx 4.1 nm on final LOA)*

For 45° offset approach track tgt along coaming line and overbank into the dive approaching apex point.

Wings	45° WS (Mnvrs A/R)
GMR	Deselect Stab or Select M+S
Throttles	Idle Idle

Roll out on LOA and track BFL through target

Airbrakes	Out
PHC	Phase change. Align tgt bar with tgt

If AGR required

CRPMD/PHC	Select AGR
NWAMS	RDR ACPT SEL lit

If Laser ranging required

LRMTS	LIVE, target range <4.3nm (and inside FLFP)

Pre-Release

Late Arm	Live
WRB/ARB	Press and hold for release

After Release

WCP1 and 2	Check for release deficiencies
Late arm	Safe
LRMTS	INHIBIT/ STBY

Notes

1. Carry out initial roll-in manoeuvre into wind to minimise BFL/HUD Tgt Bar tracking problems.

2. Aligning final LOA into wind will reduce tracking difficulty.

3. Place VV symbol approx 2° above the target in the dive.

4. Max 14 AOA in recovery with airbrakes out.

5. Employ dive/toss technique if necessary to achieve release by desired recovery altitude.

6. Errors obtained from Phase 3 target marking may be unreliable.

WARNING

> With MASS and Late Arm live, it is possible to release weapons in inverted flight if the WRB/ARB is inadvertantly pressed during the tip-in and overbank manoeuvre.

3.(S) **Low Level Ingress - Pop-up Attack ('Hornet Pop').**

Run-in

150 ft MSD and 540 KTAS, or as briefed

8 nm to target:

Throttles	Max Reheat

Pop-up Point

At 6.5 nm to target commence a 3G pull to 45° nose up

GMR	Deselect Stab or Select M+S

Passing 10,000 ft ATL roll inverted

Throttles	Cancel reheat

Pull to 45°nose down roll erect and track BFL through target

Throttles	Idle Idle
Airbrakes	Out
PHC	Phase change. Align tgt bar with tgt

If AGR required

CRPMD/PHC	Select AGR
NWAMS	RDR ACPT SEL lit

If Laser ranging required

LRMTS	LIVE, target range <4.3nm (and inside FLFP)

Pre-Release

Late Arm	Live
WRB/ARB	Press and hold for release

After Release

WCP1 and 2	Check for release deficiencies
Late arm	Safe
LRMTS	INHIBIT/ STBY

Notes

1. Aligning final LOA into prevailing wind will reduce tracking difficulty.

2. Place VV symbol approx 2° above the target in the dive.

3. Max 14 AOA in recovery with airbrakes out.

4. Employ dive/toss technique if necessary to achieve release by desired recovery altitude.

5. Errors obtained from Phase 3 target marking may be unreliable.

WARNING

With MASS and Late Arm live, it is possible to release weapons in inverted flight if the WRB/ARB is inadvertantly pressed during the pitch-back manoeuvre.

ANNEX B TO
SECTION 9 CHAPTER 1
TORNADO GR 1 TACTICS MANUAL

HEIGHT CHANNEL CORRECTION

1.(R) **ICAO Standard Atmosphere.** In common with other modern aircraft, the aircraft altimeters and ADC system in the Tornado are calibrated for the ICAO standard atmosphere. Ambient conditions that differ from the ICAO standard values of pressure and temperature result in a height reading that is in error from true altitude above mean sea-level.

2.(R) **D-Value Correction.** To reference the pressure altitude output from an altimeter based on a sub-scale setting of 1013.2mb, a D-value correction forecast by the Met Office is used. D-value is defined as the true height above mean sea level minus the pressure altitude reading when the sub-scale of an altimeter is set to 1013.2mb. The technique is simple to use and merely involves the selection of POS on the TV Tab to obtain a read-out of system height and then overwriting the POS Ht with the sum of the HUD pressure altitude reading and the forecast D-value (valid for the area and time of the attack).

3.(S) **Pressure Error Correction.** To correct for pressure errors, an empirically derived figure of +54ft was applied during Trial COBNUT to the corrected pressure altitude reading. This figure was obtained from a combination of Trial TRADAR results and additional height channel data gathering sorties.

4.(R) **Height Channel Correction Procedure.** An example of the height channel correction procedure is as follows:

Press alt (HUD Baro reading with 1013.2 mb set)	20,100ft
D-value (valid for target area and TOT)	- 680ft
PEC error	+54ft
True height MSL (POS over-written to read)	19,474ft

INTENTIONALLY BLANK

CHAPTER 2 - MEDIUM LEVEL LGB PROCEDURES

INTRODUCTION

1.(R) This chapter discusses the problems associated with laser designation from medium level, considers advice on how to employ the LGB for a medium level mission and recommends basic principles for weapon-to-target matching. It is written from the perspective of the designator (or 'Spiker') crew and has been gathered from the experiences of Buccaneer and Tornado TIALD crews who operated during the Gulf conflict. The advice provides essential reading for Tornado crews who intend dropping the LGB and have to consider planning the mission.

ACQUISITION PROCEDURES

2.(S) Usually, the Spiker aircraft will approach the target area ahead of the bomber package. The Spiker may then have to fly a tangential path or, in extreme cases, an orbit around the target area.

3.(C) **Locating the Target.** The Spike crew will be faced with the problems of visually locating the target, then tracking it with the pod. The capability to find and track the target will depend upon the following factors:

a. **Target Size.** Target size can vary from small command bunkers to large bridges. It follows that the smaller ones may be difficult to locate visually, particularly in an environment where very few identifying features may surround the target area. Area target study is vital.

b. **Weather.** Cloud cover between aircraft and target will naturally preclude the identification and spiking of the target. Hazy conditions would also add to the crew's problems.

c. **Smoke.** Smoke in the target area might help with target area identification, but could well preclude identifying the required DMPI. For this reason it is desirable that the immediate target area should not have been attacked recently. In addition, if the spiking is for more than one target in the area, the attack plan should take into account the requirement to attack the downwind target first.

d. **Aircraft Altitude.** As aircraft altitude increases then apparent target size decreases. Conversly, in conditions of haze/inversion, visiblity at a given slant range will decrease with an altitude decrease. Therefore the bombing altitude should be chosen taking into account the effects of the threat, weather, target size and surrounding features.

LASING

4.(S) **Lasing Period.** For many years, the LGB concept of operations has centred around their release from low level using loft/toss manoeuvres. For low level loft delivery, the start of target designation must be delayed until the LGB has passed the apogee of its manoeuvre thus conserving the bomb's energy and manoeuvrability. At medium level, the primary consideration is laser acquisition and it is therefore recommended that designation be commenced at LGB release. However, there may be occasions when shorter designation times are required for tactical reasons. For example, if one designator is being used to designate several targets or to reduce the amount of time spent by the Spiker in a hostile target area. Level deliveries from medium level usually have an implicit designation delay because it takes some time before the target enters the LGB seeker head field of view. This delay can be as much as 15-18 sec for deliveries from 20,000 to 25,000 ft ATL at release speeds of 400 to 550 KTAS. Hunting Engineering Ltd advise that the target should be lased for a minimum of the last 10 seconds of bomb flight, however, due to the steep impact angle, there is no maximum recommended lasing period, as in the case of low level loft deliveries. Operations in the Gulf demonstrated that continuous lasing should be adopted in order to simplify co-ordination procedures.

5.(C) **Target Obscuration.** Operation Granby demonstrated that a circular or tangential flight path could be flown without airframe obscuration of the line of sight; additionally the pod field-of-view limits were not approached.

6.(S) **Laser Detection Range.** The main factors affecting the detection of the laser spot are the range and relative position of the Spiker and the LGB, the reflectivity of the target and atmospheric effects. If lasing conditions are poor, it is recommended that the LGB is released close to the unguided forward throw range. On the other hand, good atmospheric conditions may enable extended stand-off ranges to be used. Loss of laser energy immediately prior to impact may also have an effect upon miss distances. This may occur if the laser reflected energy is hidden from the bomb's view. For example, the Spiker could be designating one side of a HAS, whilst the LGB approaches from the other.

7.(S) **Laser Codes.** The advantage of a standard single laser code is that it minimizes the chance of aircraft releasing bombs set to the wrong laser frequency. Single codes also provide the formation with an element of redundancy; if one of 2 Spikers turn back before the target, the remaining aircraft can still designate for the bomber package. When 2 codes are made available, the loss of a designator aircraft could deny some elements of the bomber package the opportunity to bomb, since in many conditions it is impracticable for the navigator to change codes in the time available.

LGB DELIVERIES

8.(S) **Bomb Release.** Since continuous lasing is recommended for medium level releases, it is not essential to know the exact moment of weapon release. However. procedures must be adopted whereby the Spiker is lasing by the time of weapon release.

9.(S) **Seeker Field Of View.** One of the considerations which has the greatest effect on LGB employment is the FOV of the seeker head. At first, the seeker FOV is restricted to longer ranges and, as the LGB falls, the FOV becomes elliptical in shape on the ground. As the bomb falls, the size and position of the ellipse changes. Consequently, for a bomb released at a range of, for example, 26,000 ft, it will not see the target until after approx 17 secs time-of-flight. Additionally, if there are deflection errors due to targetting error or drift, the initial detection may not take place along the major axis of the ellipse and there may be an increased delay before detection. Moreover, if a long laser designation delay is used, or a release range is chosen which is close to the near edge of the basket, the target would only be observable for a small proportion of the LGB trajectory.

10.(S) **Bombing Envelopes.** Generally, the front boundary of the LGB release basket is constrained by the FOV of the bomb and the rear edge is constrained by the nominal acquisition range of the laser spot. The maximum acquisition range of UK Paveway 2 will always be greater than its unguided forward throw. The following considerations were included in calculations of basket size:

a. Maximum impact velocity 900 feet per second.

b. Maximum LGB time-of-flight 50 seconds. (Limited by gas motor endurance for vane guidance).

c. Seeker head FOV 16° half-angle.

d. Seeker head assumed to detect a target at a maximum of 16,000 feet slant range. (Nominal value assumed by Hunting Engineering).

LGB performance data showing the LGB basket size for UK Paveway 2 and the ideal release point for various heights and dive angles are given at Annex A.

11.(S) **Gravity and Wind Effects.** The lack of gravity compensation in Paveway 2 causes the weapon to spend more time below the sightline than above it. The overall trajectory tends to sag below the initial seeker line of sight. The bias below the sightline also causes the average impact point to be below the laser spot for a vertical target, and short of the spot for a horizontal one. Therefore, the Spiker will always aim at the top half of a vertical target to compensate for gravity effect. Once guidance is initiated, the weapon adopts the instantaneous LOS flight path to target and at this point, the detector will attempt to align itself with the local airflow. In the case of a headwind, the bias will cause the guidance computer to stop upward corrections prematurely. The bomb may not therefore oscillate fully through the line of sight, as it was designed to do. This results in the guidance computer generating smaller, but more frequent commands than in a still air condition. It also means that the bomb may not get up onto the instantaneous LOS, causing a certain amount of trajectory sag in addition to that caused by gravity. A tailwind has the opposite effect - the bomb tends to fly upwards through the line of sight before up commands cease. This results in the beneficial effect of counteracting the gravity effect. Crosswinds cause a sideways sag in the trajectory.

12.(S) **Bomb TOF.** The maximum bomb TOF is limited by the effective duration of either the thermal battery and/or the gas generator. At release, lanyards initiate the thermal battery and the unfolding of the aerofoil group wings. In the case of 2 computer control guidance (CCG) mechanisms in service with the RAF, the gas generator is ignited after approx 2 secs. In the newest CCG (MAU-169D/B), the gas generator is not ignited until acquisition of the reflected laser energy.

LESSONS LEARNT FROM THE GULF

13.(S) **Release Parameters.** The following release parameters should be observed when planning Paveway 2 LGB deliveries from medium level:

a. Bomb time of flight should be less than 45 secs.

b. A steep angle of impact (at least 45°, and preferably higher) should be used to reduce the probability of ricochet, decrease the path length through the target, and prevent speed decay.

c. A bomb impact velocity should be less than 1020ft.sec^{-1} to reduce the risk of break-up, but greater than 640ft.sec^{-1} to maintain manoeuvrability.

d. The bomb release should be at least 2,000 ft from the minimum basket range to allow for a margin of targetting error, wind effect, and LGB unguided ballistic dispersion.

14.(S) **Tactics and Planning.** Predictability is LETHAL. When an element of predictability is inevitable - eg a necessity to attack out of sun with little cross-wind, consideration to target defences, formation package size etc - then every effort should be made by mission planners and taskers to ease the problem; in particular the 'same way - same day' syndrome should be avoided. Complacency is LETHAL. No target should be considered benign until it has safely disappeared beyond the horizon!

DETAILED PROCEDURES AND TACTICS FOR PAVESPIKE AND TIALD

15.(R) Detailed procedures and tactics for designating with TIALD are given at Chapter 3, and the tactics developed during Operation Granby for Buccaneer Pavespike bombing procedures are at Annex B.

LGB RELEASE ENVELOPES

1.(C) The parameters in Tables 9-2A-1 to 9-2A-4 are taken from data provided by Hunting Engineering, and are based upon the requirement to achieve an impact velocity of no greater than 900 feet per second. Speeds during level attacks are given as groundspeed, in dives they may be taken as TAS.

	Ground Range in Feet			
Release Height (ft)	Near Edge	Ideal Release Point (Centre)	Far Edge	Time of Flight (Secs)
0° Dive				
9,000	13,572	18,936	24,300	31
15,000	17,386	22,143	26,900	36
20,000	24,400	26,700	29,000	44
25,000	no capability	no capability	no capability	no capability
15° Dive				
9,000	10,260	15,530	20,800	26
15,000	13,855	18,602	23,350	32
20,000	21,000	23,150	25,300	38
30° Dive				
9,000	7,183	12,216	17,250	20
15,000	10,148	14,749	19,350	27
20,000	19,200	20,100	21,000	35
45° Dive				
9,000	4,490	9,295	14,100	17
15,000	9,200	12,325	15,450	24
20,000	no capability	no capability	no capability	no capability

Table 9-2A-1(C) - Performance of Paveway 2 at 400kn Groundspeed.

	Ground Range in Feet			
Release Height (ft)	Near Edge	Ideal Release Point (Centre)	Far Edge	Time of Flight (Secs)
0° Dive				
9,000	15,204	20,702	26,200	32
15,000	19,505	24,352	29,200	37
20,000	24,000	27,800	31,600	42
25,000	no capability	no capability	no capability	no capability
15° Dive				
9,000	11,176	16,538	21,900	25
15,000	16,400	20,650	24,900	32
20,000	24,400	25,800	27,200	39
30° Dive				
9,000	7,634	12,667	17,700	20
15,000	14,100	17,200	20,300	27
45° Dive				
9,000	4,758	8,679	12,600	16
15,000	14,000	15,000	16,000	25

Table 9-2A-2(C) - Performance of Paveway 2 at 450kn Groundspeed.

	Ground Range in Feet			
Release Height (ft)	Near Edge	Ideal Release Point (Centre)	Far Edge	Time of Flight (Secs)
0° Dive				
9,000	16,729	22,314	27,900	33
15,000	21,618	26,559	31,500	38
20,000	31,600	32,900	34,200	45
25,000	no capability	no capability	no capability	no capability
15° Dive				
9,000	11,980	17,490	23,000	24
15,000	19,500	22,900	26,300	33
20,000	no capability	no capability	no capability	no capability
30° Dive				
9,000	9,200	13,750	18,300	20
15,000	14,000	17,600	21,200	28
20,000	no capability	no capability	no capability	no capability
45° Dive				
9,000	9,200	10,950	12,700	17
15,000	no capability	no capability	no capability	no capability

Table 9-2A-3(C) - Performance of Paveway 2 at 500kn Groundspeed.

	Ground Range in Feet			
Release Height (ft)	Near Edge	Ideal Release Point (Centre)	Far Edge	Time of Flight (Secs)
0° Dive				
9,000	18,173	23,886	29,600	32
15,000	23,496	28,598	33,700	37
20,000	no capability	no capability	no capability	no capability
15° Dive				
9,000	13,800	18,850	23,900	24
15,000	25,000	26,400	27,800	34
20,000	no capability	no capability	no capability	no capability
30° Dive				
9,000	15,400	17,050	18,700	22
15,000	no capability	no capability	no capability	no capability
45° Dive				
9000	no capability	no capability	no capability	no capability

Table 8-2A-4(C) - Performance of Paveway 2 at 550kn Groundspeed.

CHAPTER 3 - TIALD - SOPS AND TACTICS

INTRODUCTION

1.(R) Since the original TIALD SOPs were written, the TIALD system has been fully integrated into the Tornado nav/attack system. As a result, TIALD self designation of targets and fixing is possible. In addition, all TIALD aircraft have been equipped with GPS and this has changed the fixing techniques used in Tornado navigation. These SOPs reflect these changes.

SELF-DESIGNATION OF TARGETS AND FIXING BY TIALD

2.(C) Fixing and self designation of targets using TIALD as the primary sensor will be described as Phase 4 (Ph 4) in the SOPs. Ph 4, as designed and integrated into the Tornado fix attack system, has two separate techniques. The first technique is known as passive Ph 4 and uses an angle rate measurement system to resolve errors and positions. The second technique is known as active Ph 4, it uses the TIALD laser range combined with an instantaneous pick off of TIALD gimbal angles to resolve error and positions. As the main purpose of TIALD is to guide LBGs the primary system of Ph 4 operation is in the active Ph 4 mode. However, the passive system is a useful fallback system for when the laser returns are interrupted or for peacetime training, where the firing of the laser is severely restricted.

a. **Passive Ph 4.** The principles of operation in passive Ph 4 are identical for both fixing and targeting. Passive Ph 4 requires an angular movement of the aircraft relative to the point of interest (POI) to produce best results. This obviously places constraints on the position of track relative to a POI, with the worst case being a POI directly ahead of the aircraft. Furthermore, the system has not been designed to cope with a POI directly on the beam. Ideally fix points should be positioned a few miles off track and worked when the POI is between 20° and 70° angle off the nose. Direct targeting in passive Ph 4 is obviously difficult and, if ever required, passive Ph 4 attacks should be completed in offset mode with the same limitations applied to the offset as for fixing.

b. **Active Ph 4.** The principles of operation in active Ph 4 are identical for both fixing and targeting. Active Ph 4 is a point and shoot system which updates the MC after each insert on the navigator's hand controller (NHC). Therefore it is important to remember that, unlike the passive system, the MC is only updated after each insert on the NHC and that active Ph 4 does not provide a continuous update. Active Ph 4 can be used effectively in either direct or offset attacks. Active Ph 4 has two limitations, firstly the laser requires a direct line of sight to the POI and secondly the maximum laser range is 15 nm. However, in practice, best results are obtained by firing the laser at a maximum range of 10 nm and by working the POI to as close a range as practicable (remembering to insert regularly!). For each insert the laser should be switched on for 3-4 secs, an insert made on the NHC and the laser then switched off. This technique will avoid any damage to the laser due to prolonged operation and ensure the laser is available for bomb guidance!

3.(C) **Advantages of Ph 4.** The principal advantage of Ph 4 is that it allows the aircraft to ingress, egress and attack a target effectively electronically silent. Ph 4 will reduce the risk of target misidentification as the target (or offset/fix) is thermally identified and marked on the TIALD. This in turn will reduce the possibility of collateral damage, caused by LGBs being dropped out of the basket.

PLANNING PROCEDURES

4.(R) The following points should be taken into consideration when planning a TIALD sortie:

a. **Target Orientation.** Ideally the attack direction should be chosen such that the bombs impact the target surface as nearly perpendicular as possible, to maximise penetration and minimise the risk of richochet. The profile of the designator is also constrained by the need to be able to designate the required surface of the DMPI throughout the flight of the bomb.

b. **Target Obscuration.** Whilst obscuration of the target from the designator needs to be taken into account, the flight path of the bomb should also be considered. Bomb impact angle can be used to check the clearance of the bombs' flightpath over any obstructions in front of the target.

c. **Wind.** Strong cross-winds will cause the bomb to impact downwind of the Laser mark and in extreme conditions the bomb may miss altogether. For targets over 20 feet wide, aim 1.5 feet per knot of cross-wind into wind. If the drift exceeds 16 degrees (ie the cross-wind exceeds roughly 100 kn for medium-level attacks), the target will remain outside the seeker Field of View (FOV) until the drift reduces below this figure. Also, in such conditions, when the seeker first "sees" the target, the first steering command through the "bang-bang" controls may take the bomb so far downwind that it will never recover. Smoke and dust from the first bombs to impact will obscure the target area for some time; hence plan to attack downwind DMPIs first.

d. **Sun Position.** The orientation of the sun at various times of the day causes dissimilar heating of objects and produces thermal shadows; this may improve the contrast of targets facing into sun at particular times of the day and thereby aid the optical tracker and initial target acquisition. However, sun in the rear right quarter may hinder image analysis during the attack, owing to glare on the TV TAB; this can be minimised by the use of the appropriate TV TAB Sun-visor.

e. **Thermal Cross-Over.** There are two periods in the day, one near dawn and one after noon, when the heating or cooling of the earth and the objects on it, result in a near uniform thermal response; this results in extremely reduced thermal contrast for the TICM, which in turn makes target acquisition and tracking more difficult. The most significant period is the one near dawn; during the day thermal shadows aid contrast.

f. **Target Area Defences.** The majority of designation flight profiles result in the TIALD aircraft flying belly-up to the target. If successful target designation is to be maintained, the scope for aircraft manoeuvre towards the target is limited by the risk of inducing the Laser mask. Hence, if known defences in the target area have to be over-flown, orientate the designation flight profile such that this occurs after the target. Obviously, a severe threat in the target area may mean that saving the aircraft assumes priority over completing a successful attack.

5.(R) **Route Planning.** Route planning is standard: the TIALD weighs only 190 kg and for fuel planning has a similar drag index to a single 1000 lb bomb. If routeing near to points of interest, include their positions in the plan, in order to Slave onto them as they are passed and to record on video for intelligence or BDA purposes. An ordinary radar fix plan should be formulated for each TIALD sortie. However, for each radar fix a picture of the POI should be obtained, so that the fix can be identified and marked Ph 4. In addition, a prediction of the GPS satellite coverage available should be obtained for the route. This will highlight any holes in the GPS coverage and warn the navigator to expect to have to fix using either the TIALD or radar. It is important that all planning is worked in WGS84, as this datum is used by the GPS. The GPS is the primary source to update the height channel, however, as a safeguard, a 'D' factor must be obtained from the Meteorological Office.

AIRBORNE PROCEDURES

6.(C) **Sutto.** Start up is as per normal FRCs, except that the GPS must be initialized. After start up, the TIALD pod must be harmonized to the aircraft. This is an important procedure that removes the inherent error in the system caused by the mounting of the TIALD pod. The difference between the TIALD pod and aircraft datums can be as much as 2°, which obviously would introduce aiming errors in Ph 4. The harmonization mechanics are fully covered in the TIALD ground-school. However, it is important that no height corrections, applicable to the target area, are introduced until after the harmonization is complete. Before take-off, check function of the TIALD, avoiding manually slewing up and across or the roll gimbal will hit its end-stop. If a TIALD ground cooler is not available, the pod running time on the ground should not exceed 20 minutes or it may overheat. In this case, either turn it ON with less than 20 minutes to take-off, or shut it down and turn it on in the air and fly straight and level for 2 minutes to allow the gyros to erect. Take-off with the pod in "Park".

7.(C) **En-Route.** The primary fixing sensor en-route is GPS. To back up the GPS, the TIALD pod can be slaved to the pre-planned fixes in order to confirm the kit accuracy. If above cloud and the GPS is either unserviceable, or out of satellite coverage, then a normal radar fix should be completed. As a general rule, fixing equipment should be used in the order GPS, active Ph 4 and, finally, radar. Select Park if flying through precipitation, dust or icing, or if flying below 1,000 ft in desert conditions; the zinc sulphide optical flat is highly susceptible to abrasion. Once in clear air, check pod function in Cage, Manual, Groundstab and Track, and for War or the range, check the Laser for correct operation. Check that the correct Laser code is set and check the accuracy of the Slave function by updating the MC position on a fix and then Slave to it. If passing any points of interest en-route to or from the target, Slave to them and video for recce purposes.

8.(S) **Target Area - General.** The attack profile for the designator and bombers will vary according to the type of mission. The attack profiles 1-3 (shown at Annex B as Figures 9-2B-1 to 9-2B-3) remain valid for any situation where the TIALD aircraft is not dropping a bomb. However, if the TIALD aircraft is required to bomb, then the profile flown by the TIALD aircraft must be adapted and two new options have been devised; these are detailed as Profiles 4 and 5 (see paras 14 & 15 respectively). The final choice of profile will be decided by the target size and defences. The principal difference between the new profiles and preceding ones is that the TIALD aircraft must be pointing directly at the target at weapon release.

9.(S) **Target Area - Nav Actions.** Approaching the target area, the navigator should carry out the following actions:

a. Update MC position to obtain best possible Slave and start the video recorder.

b. Select first DMPI for designation by calling it up on the right TV TAB and pressing

TBXI+TBXD, then call up second DMPI on right TV TAB.

c. Slave to first DMPI at around 20 nm from medium level. Beware of "stirring the porridge" and mis-identifying the target. A graph of lateral FOV versus range is given at Annex A. If unsure of the target area, Re-Slave to it; once satisfied with target area, select narrow FOV and Track.

d. When in track and less than about 15 nm slant range, fire the Laser for a short time to check it and to update the ranging.

e. The call of "Coconuts" comes at about the turn-in point (Point A in Figure 9-3B-1 of Annex B). If happy with the mark, tell the Pilot, who transmits it to the lead bomber (the Nav has his hands full at this stage). If at any stage you are unhappy, inform the Pilot, who transmits "STOP, STOP, STOP".

f. As the Pilot counts down from the "Pull" or "Bombs Gone", at the appropriate time, confirm with the pilot that the Laser is firing (flashing L on the TV TAB); this occurs after the appropriate time delay for loft, or at least 20 seconds to impact from medium-level. In the standard 40 second split case, the second "Coconuts" call comes 10 seconds after the first release, and in the medium-level case, the corresponding "Bombs Gone" call occurs at approximately the same time as the first bomb impacts. In this case there is no opportunity for the TIALD to reply to the second bomber's "Coconuts" call who therefore continues with the drop, unless he hears the "STOP, STOP, STOP" call.

g. Whoever first sees the bombs impact calls "SPLASH". This caters for the case where the designator Nav will not see the impact, either because he is marking the wrong target, or because the bombs missed. This is the cue for the Nav to move on to the next DMPI. If nothing has been seen after impact time plus 5 seconds, move on to the second DMPI.

h. Immediately after impact, cancel the Laser and prepare for the next DMPI; the TV TAB will be washed out by the heat of the explosion and the tracker will go into coast. The pilot counts down the time of flight of the second bomb. Use one of the following two methods for changing DMPI:

(1) Method 1 (Preferred Method)

(a) Select Groundstab and large FOV.

(b) Slew box to target area, identify target, change to narrow FOV. Track and fire Laser.

(c) Pilot cross-checks with the Nav that the Laser is firing at the appropriate time.

(2) Method 2 (Only to be used if the Slave is excellent)

(a) Press TBXI and TBXD together to get the second target and re-Slave.

(b) Identify target, select Track and fire the Laser.

(c) Pilot cross-checks with Nav that the Laser is firing at the appropriate time.

i. After second bomb impact attempt BDA by scanning target area and changing FOV as required.

10.(S) **Target Area Pilot Actions.** The pilot should carry out the following actions to assist the Nav, who is extremely busy in the target area and where he will have little capacity for anything other than TIALD operation:

a. Take route map and target area maps to aid navigation in the target area.

b. Lookout, monitor the RHWR and navigate in target area; inform the Nav of any chaff/flare requirements unless the front-cockpit combined chaff/flare programme button is fitted.

c. Make all radio calls in the target area where the Nav is busy, including relaying the calls of "Happy" or "Stop, Stop, Stop".

d. Time count-down from "Bombs Gone", or "Pull" call, to impact and cross-check with the Nav that the Laser is firing at the appropriate time.

e. Manoeuvre in the target area to evade AAA and SAMs; try to avoid turning towards the target area and inducing the Laser Mask.

f. Set 158 mils on the SBS; this corresponds to the cage position on the pod, and may be used as a last resort by day, to assist the Nav in finding the target, should the Pilot become visual with it first.

ATTACK PROFILES

11.(S) **Profile 1 - One or Two DMPIs.** A standard designation profile is shown at Annex B, Figure 9-3B-1; this allows two DMPIs to be attacked in one pass. This profile works for a 30 degree banked turn at around 450 kn groundspeed at medium-level or for a 520 kn TF turn at low-level. The radius of turn is approximately 5 miles in both cases. Having chosen the DMPIs and attack tracks, draw the designator's track line 3 miles back from, and parallel to, the DMPIs and bisect that line at the mid-point of the 2 DMPIs. The points 20 seconds either side of this represent the designator's position at each impact; 40 seconds allows ample time to change DMPIs and redesignate. A split of 30 seconds between impacts represents the practical minimum to allow the designator to re-acquire the second DMPI , track it for 20 seconds and guide the LGB successfully. The 5 mile radius turn can now be added to ajoin the straight line portion of the designator's track; the start of the turn (way-point A in Figure 9-3B-1) is 8 nm back and 7 nm offset from the first DMPI. These dimensions are only a guide and can be adjusted to fit any particular scenario. In the low-level case, deconfliction needs to be considered with great care.

12.(S) **Profile 2 - Medium-Level, Single DMPI.** When attacking a large target such as a bridge, with 2 bombers executing a simultaneous release, unless the bombs arrive at the target very close to each other, the second set of bombs to arrive will tend to track the Laser spot on the rising smoke plume from the first; this may cause them to miss. To minimise this effect, the bombs should be released as close to simultaneously as possible, and the designator should be Lasing approximately down the flight path of the bombs at impact. The profile shown in Figure 9-3B-2 achieves this. The designator flies 20-30 seconds behind the bombers, but should normally fly lower, to avoid the bombers appearing in the designators FOV on the run-in.

13.(S) **Profile 3 - Low Loft, Single DMPI.** In Profile 3, shown in Figure 9-3B-3, the designator flies 20-30 seconds trail on one of the bombers and commences a TF turn at 7 nm to roll out after around 90 degrees. If necessary the designator can offset to the outside of the formation as required. Standard ingress speed is 520 kn groundspeed with a max dry loft manoeuvre commencing at 22 seconds TTG. Release occurs at approximately 22 degrees and optimum delay for designation is 18 seconds from pull-up. If the cloud base is lower than 1500 ft

ATL, but with a minimum of 800 ft ATL, then a mini-loft commenced at 15 seconds TTG, with continuous designation should be used. Mini-loft release occurs at approximately 10 degrees nose-up. Careful attention must be paid to deconfliction between the bombers recovering to low-level and the designator.

14.(S) **Profile 4 - 3 Separate Discreet DMPIs (TIALD Aircraft Bombing).** When attacking a target containing 3 discreet DMPIs, during the first pass, the TIALD aircraft marks the bombers DMPIs, with a nominal 30 - 40 secs between bomb impacts. The TIALD aircraft then completes a re-attack on his own DMPI. The advantages of this profile are a high probability of a hit on 3 DMPIs, the priority DMPI can be re-attacked by the TIALD aircraft if it is missed on the first pass, BDA is obtained of the bombers' targets and errors in bomber timing can be tolerated. The disadvantages are that the TIALD aircraft re-attacks, (this disadvantage can be reduced if 2 TIALD aircraft re-attack after designating for 4 bombers as cross cover can then be maintained), TIALD aircraft require extra fuel for re-attack (ideally re-attacks should be in the order of 10 mins) and the loser plan is complicated. The serviceable TIALD aircraft could realistically be expected to designate for 3 bombers on the first pass and on the re-attack designate for himself and the remaining bomber.

15.(S) **Profile 5 - One Large Complex with 3 DMPIs (TIALD Aircraft Bombing)** When attacking one large target complex with 3 DMPIs, e.g a large factory or HAS site, all aircraft bomb in 30 sec stream, in the order, bomber, TIALD, bomber. TIALD drops in offset mode while marking first bomber's target. This gives good target compression, without any re-attack, and the loser plan is simple with a minimum of 6 mins between attacking 3 ships; the serviceable TIALD aircraft could mark for both elements. However, timing for this attack is critical, and targets must be easily identified as the TIALD aircraft is at a range of 7-8 nm when the first bomber drops. Also time to slew between DMPIs is only 10 secs leaving little time to overcome any difficulties encountered. The profile puts a high workload on the crew of the TIALD aircraft, increasing the probability of a miss and degrading lookout.

16.(S) **TIALD/Bomb Masking.** Bombs carried on TIALD aircraft are not included in the laser mask model and may encroach on the IR picture. To avoid problems, targets and fixes should be positioned to the left of the aircraft.

17.(S) **Timing.** The leader's target overflight time is used as the Datum. As a general rule, the leader should aim not to get late and the No 2 not to be early. A medium-level attack speed of around M0.72, or a low-level attack speed of 520 kn groundspeed, allows reasonable flexibility for TOT maintenance.

18.(S) **TOO LGB.** With the advent of Ph 4, TIALD can be used to obtain an accurate latitude and longitude of any POI the navigator can mark. This position can be changed to a target and attacked using Ph 4.

19.(S) **LTM for CBU87 Attack.** TIALD could be used as an airborne LTM for CBU87 dive toss attacks. At medium level, target acquisition by a bomber is difficult, however, if TIALD identifies a target and passes an accurate latitude and longitude to the bombers, they can perform a high dive MTR attack. The bomber dives on the passed kit position and calls diving at the top of dive. This is the cue for the TIALD laser to be fired to mark the target. Once the bomber has identified the target he deselects MTR and converts to a visual dive-toss attack. Notwithstanding, co-ordination is required between bombers and TIALD to ensure the TIALD aircraft is in a position to mark the target when required.

20.(R) **Target Study.** Target study is vital to the success of TIALD operations, perhaps more so than for any other type of attack. The orientation of the TIALD picture can itself be disorientating.

21.(S) **Routine SOP RT Calls.** The following SOP RT calls should be briefed and used:

Position	**BOMBER'S Call**	**TIALD'S Reply**
En Route	DATUM	Acknowledge
30 secs to bomb release	COCONUTS	HAPPY/STOP, STOP, STOP
At pull-up for Loft	PULL	(nil)
At release	BOMBS GONE	----
At impact	SPLASH	----

22.(S) **Addition to Radio SOPs.** In the event that a bomber is approaching 10 secs to release and has not received a "HAPPY" call from the TIALD aircraft, as a prompt to the TIALD aircraft he should transmit "SAXON 1 (etc) 10 secs". Nevertheless, if a "HAPPY" call is NOT transmitted by the TIALD aircraft, then the bomber must go dry.

23.(S) **TIALD Loser Plan (TIALD Aircraft Not Bombing).** In the event of one of the TIALDs going unserviceable pre-target, the minimum practicable time delay for the designator to position for a re-attack is usually 6 minutes. Hence the stream of bombers needs to be separated by 6 minutes. If the rear TIALD loses, the lead TIALD is the only aircraft affected and positions for re-attack 6 minutes after the first. If the lead TIALD loses, then the SOP is for the lead bombers to position for re-attack at Datum plus 12 minutes, designated by the rear TIALD. However, for fuel reasons, extended range missions may preclude this option; in this case the rear TIALD can be briefed to fly close behind the lead such that he can catch up the lead bombers if required. If the lead TIALD remains serviceable, the rear TIALD can split at a pre-planned point, just prior to the target, to lose time to designate for the rear bombers. TIALD deconfliction (by height split for example) needs to be fully briefed, to cater for the case where both aircraft are in the target area at the same time. However, always bear in mind that target defences may render re-attacks inadvisable. The following SOP RT calls should be used to cover the TIALD loser plan:

CALL	MEANING	REPLY
PEPPER	Lead TIALD is U/S	Lead bomber replies with new Datum. (Normally Datum plus 12). Rear TIALD acknowledge.
NUTMEG	Rear TIALD is U/S	Lead TIALD Acknowledge.

24.(R) **RTB.** Ensure park is selected before landing.

EXECUTION PROBLEMS

25.(S) **Timing Problems.** Any major timing problems can be corrected pre-target by a Datum change. Notwithstanding the general rule of the first bomber not getting late, if he is forced to evade near the target and becomes a few seconds late, he can still call it; his No 2 will then have to conform to this change by losing time, whilst the designator merely flies wide of the turn-in point (point A in Figure 9-3B-1) to lose time. Similarly, if the designator is late, he flies inside the turn point towards the target and executes a harder turn to parallel the DMPIs. If the second bomber is more than 30 seconds late, the TIALD will usually be unable to designate the target successfully as the servo end-stop will have been reached. At medium-level, the onset of the servo end-stop can be delayed by bunting the aircraft; a bunt of 5-10 degrees will delay servo end-stop by 10-15 seconds. In this case, either re-attack, attack a pre-briefed secondary target or RTB with the bombs.

26.(S) **Cloud.** At medium-level if cloud obscures the target, the designator will either have to fly below it or, by day if the cloud is patchy, nearing the target area the designator can dive at the target to maintain clear line of sight. The brief should cover bad weather options and include the minimum heights ATL to be flown commensurate with the target defences. The plan may result in the bombers being above the designator at release; deconfliction needs to be fully briefed between the bombs' flight path and that of the designators. The bombers are then only to drop when they have positively identified the target. Two common scenarios in reduced cloudbase are outlined in Figures 9-3C-1 and 9-3C-2 at Annex C.

27.(S) **Bomber Kit Problems.** In the case where simultaneous drops from 2 aircraft are planned, both aircraft should carry out an Auto attack; if one aircraft fails to get a good target mark or has degraded kit, the crew can select Rev and fly on the wing of the other aircraft (including the TIALD), advising the "problem" over the radio. At 3 seconds to release, the Auto bomber counts down to release and the degraded bomber pickles either on the call, or by day, as the other's bombs are seen to fall. This option does not exist at night for low-level operations! If the pairs pickle option does not exist within a medium-level plan, and the bomber is slightly unsure of his kit or the mark, select Rev and pickle at 2 seconds to Auto release (this corresponds to the centre of the basket and therefore maximises the probability of being within it), or use the table, graphs, or the formulae at Annex D and pickle at the given range. At medium-level by day, if the pilot can see the target, one option is to perform a 30-45 degree, phase 2, 3 or TOOC dive-toss attack. The final REV dive-toss option, is to perform a visual 45 degree dive, place the VV on the target, pull 3g and pickle when the dive angle has reduced by 15 degrees (ie. around 30 degrees nose down); this profile results in a height loss of 6,000 ft.

28.(S) **Designator Kit Problems.** At low-level by day, if the designator's kit is degraded, OTFs (planned or unplanned) can be used to update degraded kit or if the radar fails. However, this option does not exist at medium-level; if the designator loses his radar or his kit is degraded, by day or night, he can fly on the wing of another aircraft approaching the target area, whose kit is known to be accurate, and perform an "Alternative OTF" (see MOPs). On a count down, the designator aircraft pilot presses "Store PP", whilst the other aircraft's Nav presses "POS" and then reads the position across to the designator Nav, who then carries out the alternative OTF on this position. Alternatively, by day, the designator pilot can set 158 mils on his SBS and, if he sees the target, can fly the SBS onto the target with the pod in Cage; once the Nav has acquired the target area, he selects GSTAB or TRACK and continues as for a normal attack.

TIALD HANDLING

29.(S) Handy hints to obtain the best results from TIALD and to avoid the major pitfalls are given below:

a. Do not Slave too early to a target, "stir the porridge" and mis-identify the target; as a guide, for medium-level, Slave no earlier than 20 nm and if unsure keep re-Slaving to the target. The Slave should put the point of interest somewhere in the narrow FOV box. As it is only accurate to around 1 degree, the closer you are to the target, the more accurate Slave will become. The FOVs are approximately 3.5° x 2.4° in narrow and 10° x 6.7° in wide.

b. Do not Slave to the target until there is clear line of sight between the pod and the target, or the Laser mask will be induced and the aircraft structure will probably obstruct the TIALD's view; this is especially pertinent during a re-attack when turning towards the target area.

c. If the tracker box is jittering, and/or goes into coast continually, the video tracker is having difficulty tracking. In this situation, keep re-initialising Track by pressing the insert button on the NHC. The tracker will tend to run along line features such as runways or large bridges; if possible track on a point with an across feature. The tracker will also have difficulty tracking in conditions of poor thermal contrast. Try to maximise the contrast within the tracker box by using TBXI/TBXD; retrack immediately after changing box size to maintain the desired position. In all cases, if the tracker fails to maintain the desired point, select GSTAB. Occasionally there may be insufficient NHC authority to maintain the desired position; as a last resort select Manual, or re-Slave.

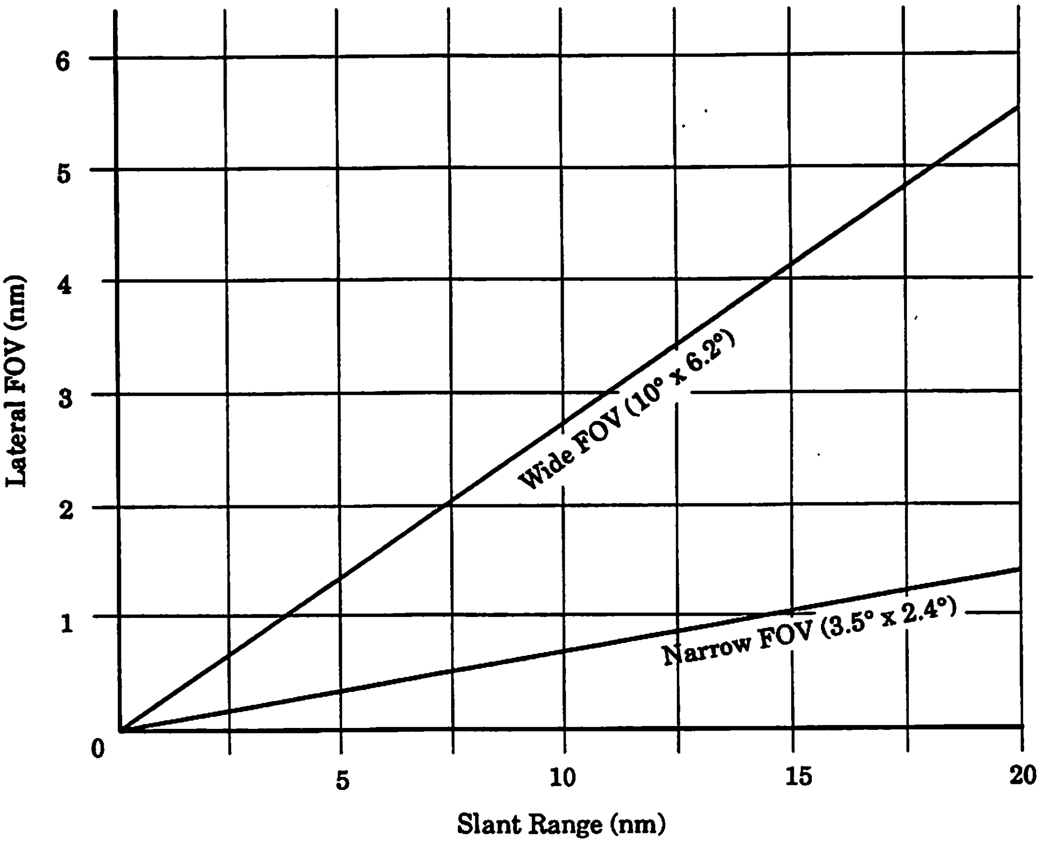
d. Do not leave the Laser firing whilst changing DMPIs, or the second bomb's flight path may be detrimentally influenced.

e. At low-level, the Laser takes 1 minute to cool to its original temperature after firing for 1 minute; after 2 minutes firing, it takes 6 minutes to cool down.

f. If at medium-level, the picture starts to jitter as the servo end-stop is reached, command the pilot to bunt 5-10 degrees; this will gain a further 10-15 seconds designation time and incur a height loss of around 2,000 ft.

INTENTIONALLY BLANK

TIALD - LATERAL FOV v RANGE



INTENTIONALLY BLANK

ANNEX B TO
SECTION 9 OF CHAPTER 3 OF
TORNADO GR1 TACTICS MANUAL

ATTACK PROFILES

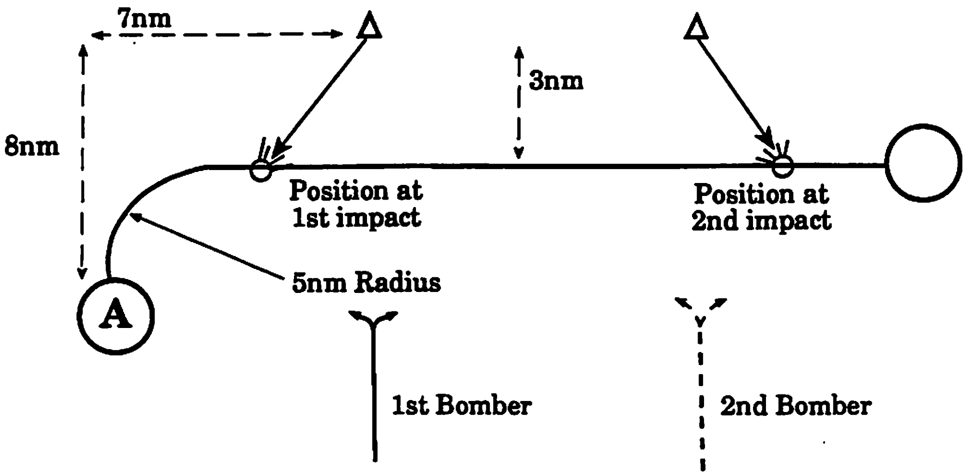


Figure 9-3B-1 (C) - Profile 1 - 2 DMPIS

△ Target

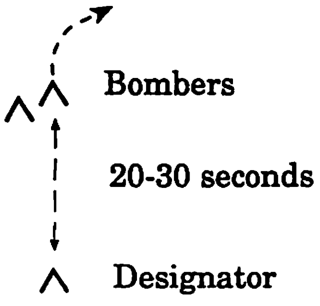


Figure9-3B-2 (C) - Profile 2 - Medium-Level - SINGLE DMPI

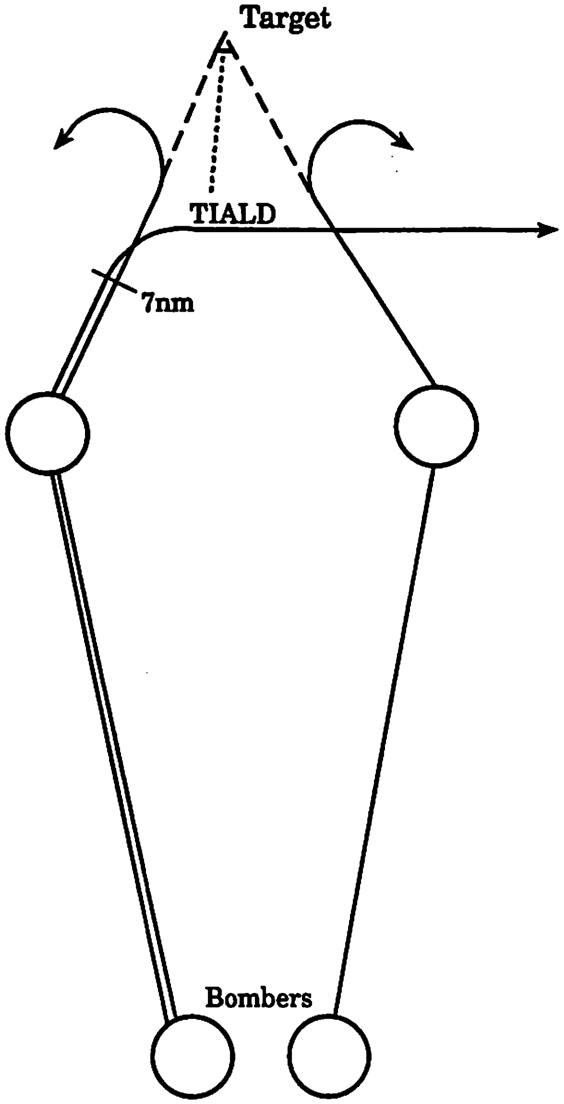


Figure9-3B-3 (C) - Profile 3 - Low-Loft, SINGLE DMPI

ANNEX C TO
SECTION 9 OF CHAPTER 3 OF
TORNADO GR1 TACTICS MANUAL

LGB - MEDIUM LEVEL PROFILE IN REDUCED CLOUDBASE

1.(R) The two diagrams below outline one way of LGB/TIALD deconfliction. The designator will need to descend prior to the turn at Point A to assess the weather conditions below cloud. If the IR visibility below cloud is good, the Figure 9-3C-1 illustrates the method for retaining maximum stand-off, together with the maximum designation time. If the visibility is poor and the TV TAB image lacks sufficient definition at A, then the designator should delay turning for 15 seconds, to press in closer to the target area to stand-off at 1 nm, as shown at Figure 9-3C-2; however maximum designation time will be reduced. Some targets may even allow the designator to fly beyond the target and designate back towards the bombers; however, target defences may render the close-in option inadvisable.

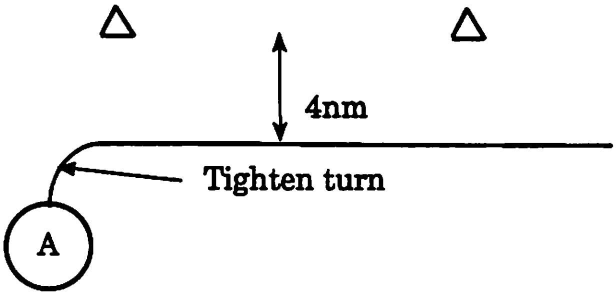


Figure 9-3C-1 (R) - Profile - Good IR Visibility Under Cloud

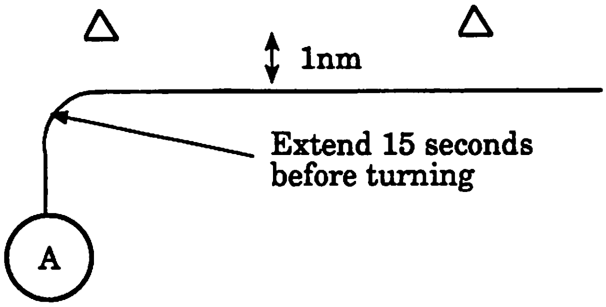


Figure 9-3C-2 (R) - Profile - Poor IR Visibility Under Cloud

INTENTIONALLY BLANK

BACK-UP LBG RELEASE DATA

1.(R) In the event that the pairs pickle option does not exist (within the medium level plan) and there is doubt as to the accuracy of the kit or the mark, then a table, formulae or graphs may be used to determine the optimum release position. The table is given below, the formulae options are at paragraph 2 and the graphs follow thereafter.

		AUTO	REV(See Note 2)	
RELEASE ALTITUDE (Feet)	GROUND SPEED (Knots)	1000 LB FF RELEASE RANGE (nm)	BASKET CENTRE RELEASE RANGE (nm)	WIND CORRECTION per 100Kn Head/Tail (nm)
25,000	400	4.2	4.4	±0.2
	450	4.7	4.9	
	500	5.1	5.3	
	550	5.5	5.7	
20,000	400	3.8	4.0	± 0.3
	450	4.2	4.4	
	500	4.6	4.9	
	550	5.0	5.2	
15,000	400	3.3	3.6	± 0.4
	450	3.7	3.9	
	500	4.0	4.4	
	550	4.3	4.7	

NOTES:

1. Ranges are plan range.
2. Rev: for Head wind, **subtract** allowance.
   for Tail wind, **add** allowance.

Table 9-3D-1 (R) - LGB Medium Level Release Data

ALTERNATIVE METHODS OF CALCULATING REV RELEASE RANGE

2.(R) Alternative methods to using the Table are to calculate the centre of basket range (R') in one of the 2 following ways:

a. **Method 1 - Basic Empirical Equation**

The Rev release range, R', can be calculated from the following formula:

$$R' = 0.085 \times Ht + 0.007 \times GS - 0.4 \pm 0.003W$$

where

R' = Plan Range from basket centre to Target.

Ht = Height above target level in thousands of feet.

GS = Ground Speed in Knots.

W = Headwind component in knots (ie for headwind subtract and for tailwind add).

For example:

GS = 450 kn Ht = 20 (ie 20,000 ft ATL) W = 50 kn (ie 50 kn headwind component)

Therefore $R' = 0.085 \times 20 + 0.007 \times 450 - 0.4 - 0.003 \times 50$

=> $R' = 1.7 + 3.15 - 0.4 - 0.15$

=> $R' = 4.3$nm. (From the tables, R' = 4.25nm)

This formula produces results accurate to within 0.1nm.

b. **Method 2 - Correction Factor Application**

A variation of the above equation involves taking a known figure for R' at say 450 kn and 20,000 ft and apply corrections:

From Table 8-2B4-1:

$$R' \text{ (450kn/20,000ft)} = 4.4\text{nm}$$

Then:

Add/substract 0.085 nm per 1,000ft above/below 20,000ft ATL.
Add/subtract 0.07 nm per 10kn groundspeed above/below 450kn.
Subtract/add 0.03 nm per 10kn wind head/tail.

For example:

GS = 430 kn Ht = 22,000ft W = 30 kn (headwind component)

Then:

$$R' = 4.4 + 2 \times 0.085 - 2 \times 0.07 - 3 \times 0.03 = 4.34 \text{ nm}$$

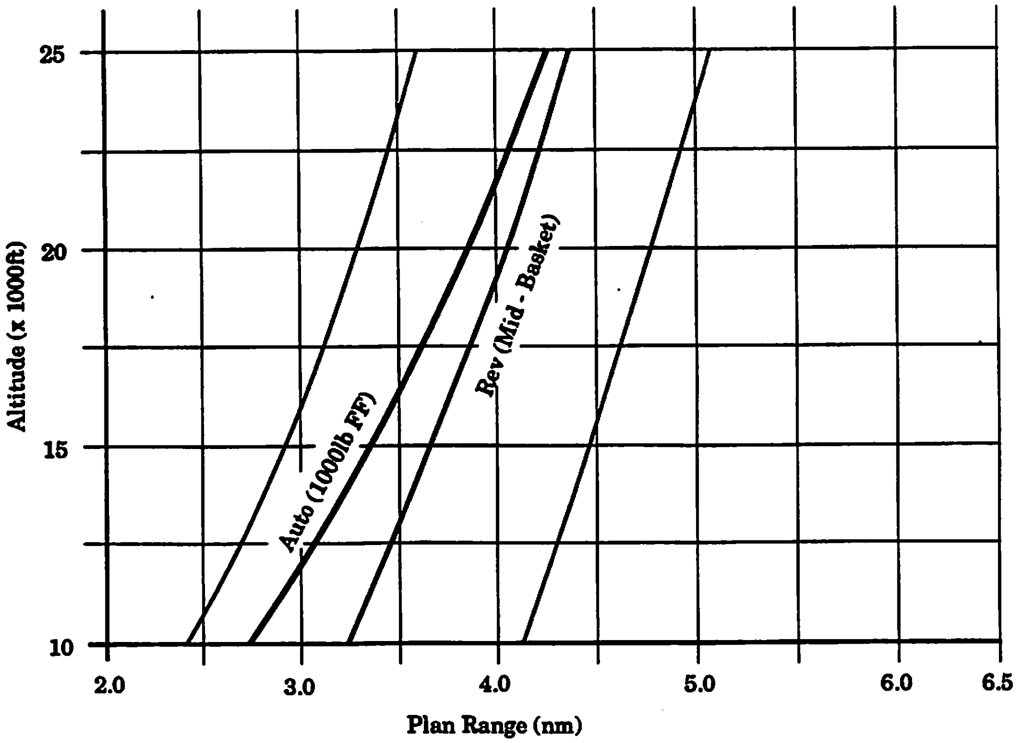


Figure 9-3D-1 (C) - LGB Envelope at 400 Kn Groundspeed

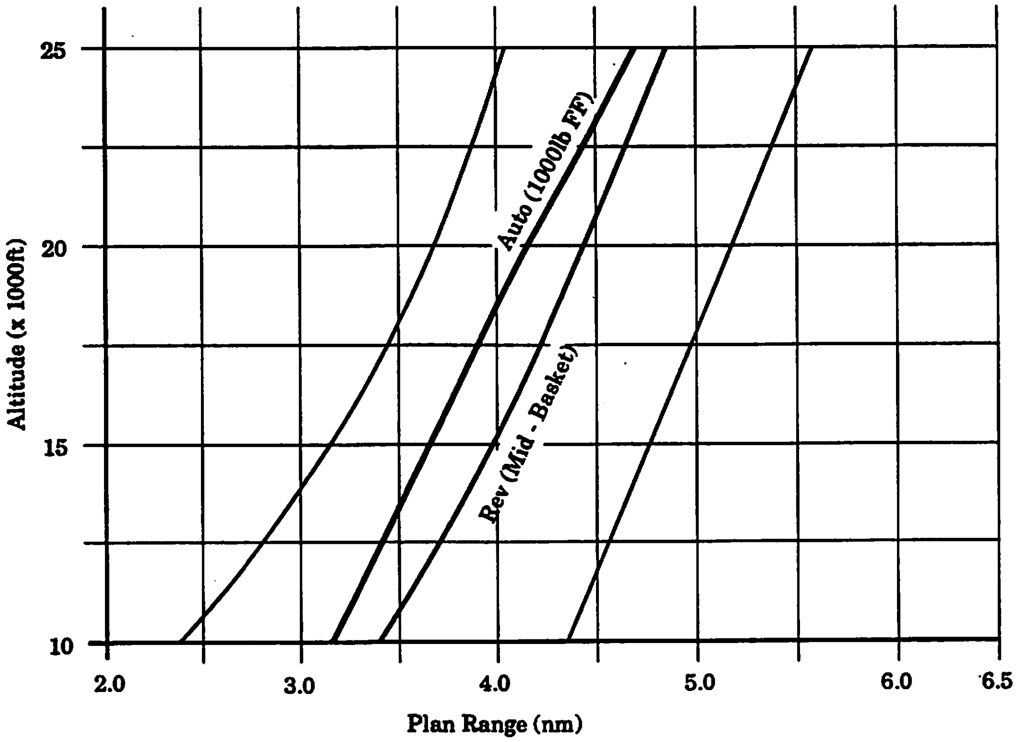


Figure 9-3D-2 (C) - LGB Envelope at 450 Kn Groundspeed

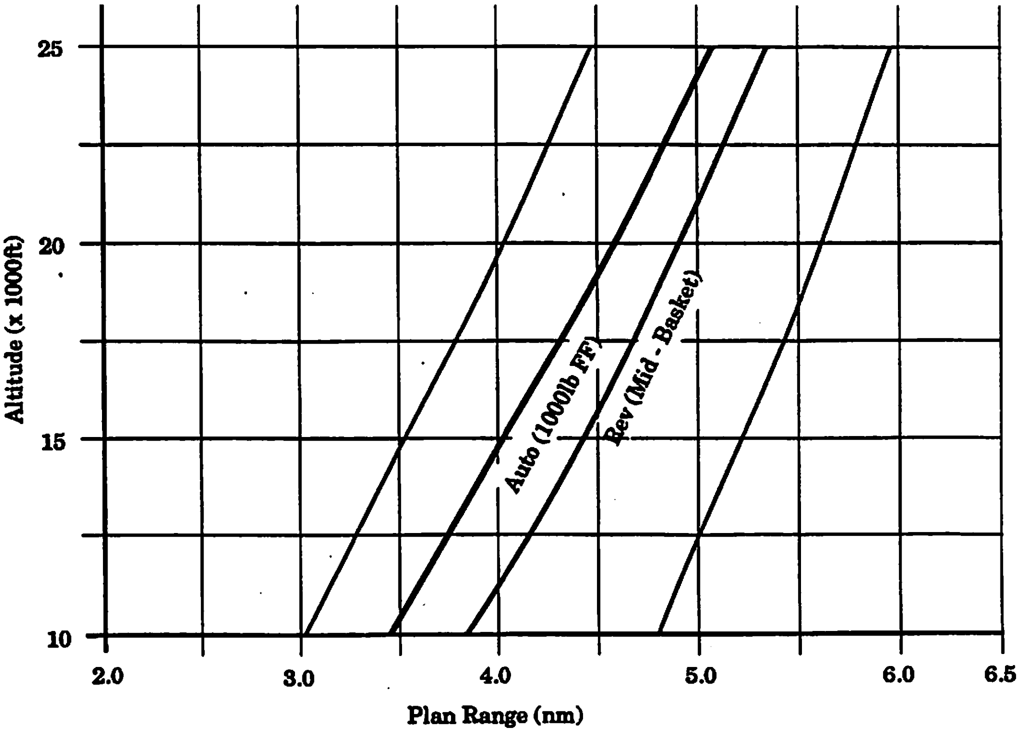


Figure 9-3D-3 (C) - LGB Envelope at 500 Kn Groundspeed

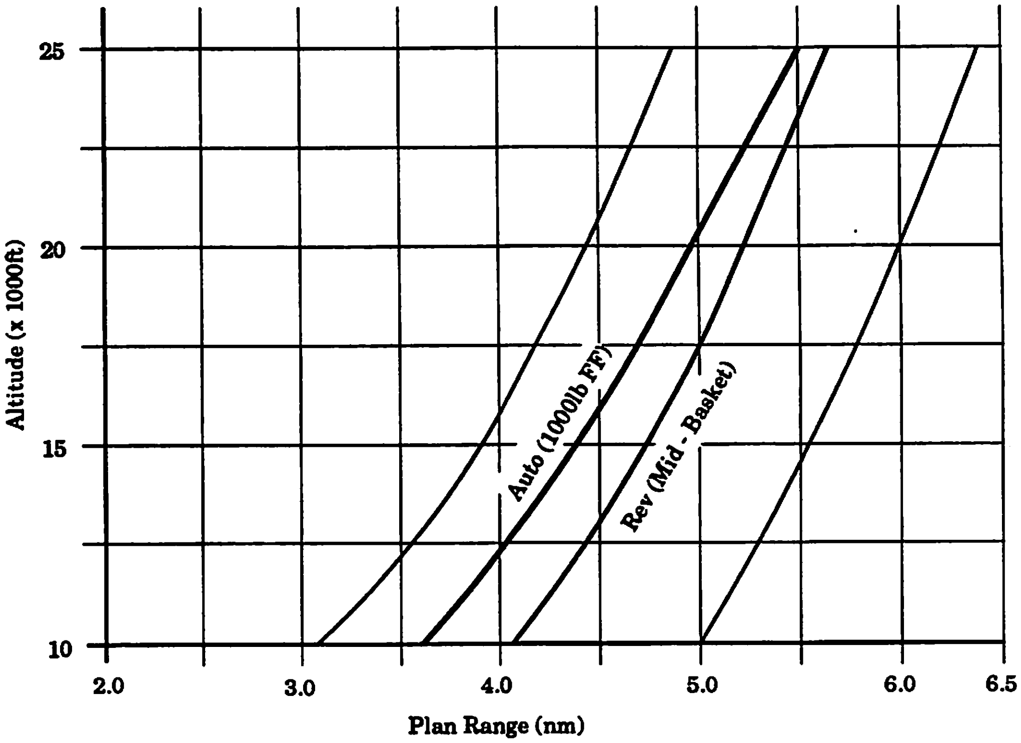


Figure 9-3D-4 (C) - LGB Envelope at 550 Kn Groundspeed

CHAPTER 4 - LASER TARGET DESIGNATOR / REMOTE TONE GENERATOR - PROCEDURES AND TACTICS

INTRODUCTION

1.(R) The Remote Tone Generator (RTG) is a small black box carried by the navigator which, when triggered, emits an encrypted tone over the UHF frequency in use by the aircraft. This in turn is received by a pre-positioned PRC 344 or similar compatible UHF radio coupled to a Laser Target Designator (LTD). This activates the laser marker thus marking the DMPI for an LGB. These procedures have been developed by No 13 Sqn RAF in conjunction with the SAS and CTTO.

THE RTG

2.(R) The RTG, or Switching Unit as it is known to some users, is a relatively simple piece of equipment and therefore fairly reliable. It measures approximately 4 x 3 x 2 inches and comes complete with a strap for securing the unit to the navigator's left leg, and a mic/tel connector which plugs in-between the LSJ and helmet portion of the mic/tel lead. This is less than ideal as it results in a spaghetti of loose wiring.

3.(R) The RTG is powered by a single 9volt rectangular battery. A functional check should be carried out by pressing the initiate button and ensuring the red/amber light illuminates for 12 sec (the standard run time of the tone).

4.(C) Hidden in the end of the RTG is the tone selector. A total of 8 tones are possible, 1-7 are secure and 8 is a 1 KHz test tone which is the same as that made by the aircraft V/UHF radio.

LASER PRF

5.(C) The LTD in not multi-PRF capable. Preset PRFs are "studded" on the LTD as Studs 1-6, these equate to 1732, 33, 34, 35, 36 and 37. Note that the training code of 1688 is NOT available. The LTD operators are trained and will expect to use the STANAG PRF ie 1732 etc, so PRFs should be passed in that format.

OPERATIONAL EMPLOYMENT

6.(C) The concept of employment is that ground forces, typically special forces, will pre-position an LTD in hostile territory to mark an important target/DMPI. The team can then depart the target area and the LTD lies dormant until triggered by the LGB aircraft, thus lasing the target. The LTD team can then retrieve the LTD if the tactical situation permits. It should be noted that LTDs are in relatively short supply and it is therefore likely that the unit will be retrieved. Depending on the tactical situation, the LTD may be manned or possibly under observation from a distance.

PLANNING

7.(C) The vast majority of the target area planning will be done by the forces on the ground. They will dictate the position of the LTD, the DMPI, and Best Attack Heading (BAH), which should equate to the reciprocal of laser E-max. To this end a laser Designator Target Briefing Sheet has been produced which contains all the necessary target details. An example is at Annex A. All UK special forces are currently issued with this sheet. In an ideal world they would plan the attack with the aircrew before departing for the field; which may be possible if special forces and aircrew are collocated at a JFHQ. The laser code, RTG code and possibly the TOT would be dictated by the tasking agency.

8.(C) Having received the briefing sheet to supplement the ATM, the IP to

Tgt planning can begin. Try and keep to the BAH and always within ± 30°; this gives the bomb the best chance of acquiring the laser energy. The target run is planned as a standard 520 kn dry power low loft, pulling up at 23 sec TTG. The LTD team may have specified a recovery direction based on the SAM/AAA threat and terrain in the target area, so try and use that. Mini-loft is available as a back-up option but should be used in poor weather only (cloud base 700-1,200ft) and not planned as a primary option.

EXECUTION

9.(R) **Initial Checks.** On start-up carry out a functional check of the RTG on the Sqn discrete frequency as follows:

a. 'Stand-by for wibble check'.

b. Initiate RTG, check light illuminates.

c. Press PTT button (tone should be audible).

d. 'Good wibble'.

When airborne nothing further should need doing until nearing the target area, then check:

e. Correct RTG code is set.

f. Check-out / change to the pre-briefed LTD radio frequency (do not check-in).

10.(C) **Loft Profile.** Continue with the IP-Tgt run and pull-up normally, the pilot flies a standard loft delivery and recovery; the Nav carries out the following actions:

a. At weapon release hack the stopwatch.

b. At 5 sec initiate the RTG, check light on.

c. At 10 sec PTT, the recommended transmission is a single 1 sec long tone, (Note. The signal for the laser to fire is the tone cut out, not the start of the tone **so do not PTT for longer than necessary**).

d. Ensure tone is heard to go out.

e. Check out the frequency if a pair or more.

11.(C) **Mini-loft Profiles.** If Mini-Loft has been planned from the start the best option is to plan an 'aim short', and use optimum (delayed) designation. The optimum aim short is 1,500ft, with a 5 sec post-release delay. The aim short can be achieved by using an offset to simulate a false Tgt position. However, a simpler and more robust tactic is to use a VFT of **minus** 999 ft, with a 5 second delayed designation, using the following profile:

a. Normal 12 - 15 sec TTG pull-up.

b. At weapon release hack the stopwatch.

c. Initiate RTG.

d. At 5 sec PTT.

e. Recover normally.

If Mini-Loft is being used as a fall back option to a full loft attack, a simple procedure is to accept the fact that you are at the front edge of the envelope (without an aim short) and use continuous designation with the profile below:

f. Normal 12 - 15 sec TTG pull-up.

g. At weapon release initiate RTG and PTT immediately.

h. Recover normally.

MULTI-SHIP/ MULTIPLE DMPIs

12.(C) There are several combinations for multi-ship/multi DMPIs e.g. a pair on a single DMPI, a pair on two adjacent DMPIs, a pair on two widely split DMPIs or multiple aircraft on several DMPIs; each needs careful consideration, particularly in the planning phase.

a. **Pair/Single DMPI.** The Pair/Single DMPI task is by its nature likely to be a night attack; this effectively rules out a pairs loft profile, leaving simultaneous loft as the best profile to employ. Plan to put the aircraft split either side down the BAH and ensure both have identical TOTs. In this case the LTD/RTG planning is simple; have both aircraft on the same frequency, use a silent check -in, and only one aircraft is to 'tone'. Brief a code word to call if the primary RTG fails to tone, the second jet then tones instead. Both LGBs need the same laser code and only one LTD is required. This method also ensures both aircraft can communicate if flight safety dictates.

b. **Pair/Split DMPIs.** For a Pair/Split DMPIs and assuming both BAHs are compatible, plan simultaneous loft to achieve identical TOTs unless otherwise briefed. One aircraft can tone for both LTDs on the same frequency, however, the LGBs will need separate laser codes for each DMPI. Brief an RTG failure code word as for the Single DMPI.

c. **Pair and Different DMPIs.** If the DMPIs are widely split then consider using 2 different radio frequencies or with split TOTs and different RTG codes. Bear in mind that the aim is not to compromise the RTG frequency prior to tone transmission, thereby virtually guaranteeing the tone is not jammed.

d. **Timing.** The LTD runs for exactly 32 sec and is then ready for a further tone reception. With this in mind, simultaneous loft is obviously a good option but successive aircraft should not plan to be too close to the 32 sec point. Plan a minimum of 40 - 45 sec split. Experience shows that 45 sec actually allows the LTD team, if collocated, to relay the laser if required.

e. **RTG Failure.** Within a pair, the second RTG can back-up the primary should it fail. However, should both RTGs fail or if the task was for a single aircraft, then 2 other options are possible:

(1) Firstly, RTG code 8 is a 1 KHz test tone, this can be simulated by the aircraft radio; note that the frequency must be selected on the back box and the radio button and PTT must be pressed simultaneously. This technique can be used when no RTGs are available or operationally by calling '*Switching unit 8 Go*' on the radio in the loft manoeuvre. Allow time for the LTD team, if collocated to select code 8 on the LTD and then transmit the 1 KHz tone. Be aware that not all laser designators are capable of selecting RTG 8 so this may not solve the problem.

(2) Lastly, and if all else fails, call '*Lima, Lima Now*' on the tone frequency and the LTD team, if collocated, will initiate the LTD manually. This is an agreed standard call.

COMMON PROBLEMS

13.(C) There are several factors which will and have caught out the unwary and resulted in wasted LGBs, namely:

a. Do not use the published LGB WPU codes, use the standard 1,000lb FF codes; this ensures that with the resulting slight fall short the LGB has the best possible chance of acquiring the laser basket.

b. Do not talk or transmit anything over the RTG tone, this 'locks-out' the LTD which then needs to be reset manually before it is able to lase. Bear in mind that the team may not be close enough to realise it has locked out or to reset it.

c. Pilots should remain silent during the pull-up and initial recovery phase until the 1 sec tone is over, except for vital flight safety calls.

d. The LTD can have a selected time delay so that for example the LTD activates 11 sec after tone generation,; the Tornado operator should only expect to see '0' time delay on the LTD briefing sheet, anything else should be queried with the tasker. The time delay facility is normally used for Jaguar/Harrier Ops, typically set at 11 sec.

MEDIUM LEVEL OPERATIONS

14.(C) Low level operations using LTDs and RTGs have been practised by Harrier, Jaguar and Tornado aircraft many times in the past and these procedures have been developed from practical experience backed up by trial results. The same cannot be said for medium level operations. Although LGBs have been delivered from medium level with both Pave Spike and TIALD designation, no work has been carried out using LTDs or RTGs. The following recommendations are based purely on academic research and should be validated by trial before being used operationally.

15.(C) All the planning considerations for normal medium level LGB operations apply as well as two further technical considerations - will the bomb receive enough laser energy and when should the RTG be initiated.

a. **Received Laser Energy.** The amount of laser energy received by the bomb is dependent on a number of factors including, power of designator, atmospheric conditions, range of designator from Tgt, range of LGB from Tgt, reflectivity of Tgt and approach angle of LGB to Tgt. It is worth looking at the last 2 points in more detail. The amount of energy reflected towards the incoming bomb depends upon the angle of the surface being lased and upon the reflective qualities of the surface. From a perfect reflector all the laser energy will be reflected in a thin beam along E max whereas from a poor reflector the energy will be scattered. The LTD has a very short wavelength (about 1 micron) so that most surfaces appear rough and will scatter its energy. On a low level profile the bomber approaches the Tgt within ± 30° of E max to capitalize on the maximum reflected energy. A bomb dropped from a level 20,000ft delivery will approach the target at an angle of approximately 50°, well outside the optimum. Will it receive enough laser energy to guide? Although ± 30° is recommended, on Trial TROPICAL successful deliveries were achieved at angles up to 60°, so there should be enough laser energy for the bomb to guide. On an optimistic note the Australian Air Force has successfully dropped LGBs from up to 30,000ft with ground designation.

b. **RTG Timing.** Once initiated by the RTG the LTD fires for 32 secs. Bombs dropped from medium level can have a time of flight (TOF) in excess of this and therefore if continuous designation is used the critical terminal stage of flight would be unguided resulting in bombs missing targets. It follows therefore that a delayed designation should be used. Also for the first 15-18 secs of flight the bomb will not be looking at the target so there is no benefit in continuous designation. A 15 sec delay is recommended for a 20,000ft delivery. For steep dive attacks the bomb is looking at the target and theoretically, as long as the TOF is less than 32 sec, continuous designation is possible. However, a wise man would allow a margin of error and a maximum of 30 sec continuous designation is recommended for steep dives.

SUMMARY

16.(R) In summary a medium level delivery with a ground designation should be possible from a Tornado but many things need to be considered and each case must be looked at individually and carefully planned.

INTENTIONALLY BLANK

LASER DESIGNATION TASKING SHEET

A.	T.O.T.	
B.	Tgt Location	
C.	Tgt Elevation	Feet
D.	Designator Location	
E.	B.A.H.	Degrees True
F.	S.U./T.T.G. Code	
G.	Laser Code	
H.	Radio Frequency	
I.	Time Delay	
J.	Tgt Description Location and Type of Threats Obstacles on LGBs Flight Path	

Note: The Tasking Sheet is to be graded SECRET UK EYES B when complete

INTENTIONALLY BLANK

Section 10

ALARM Operations

Chapter 1 **SEAD - General**

2 **ALARM System Description**

3 **ALARM Tactics**

AWC/LRMP/OAE
MC 254
19 MAY 1995
HQ 18 GROUP

CHAPTER 1 - SUPPRESSION OF ENEMY AIR DEFENCES - GENERAL

INTRODUCTION

1.(U) Experience has shown that, when faced with an enemy who has a strong surface-to-air defence system, defence suppression can greatly reduce loss rates and help sustain offensive air action. The extremely low Allied air loss rates sustained during the first two weeks of the Gulf War were due in large part to very effective defence suppression. Target sets include radars and other sensors, surface-to-air missiles and anti-aircraft artillery batteries. Suppression of Enemy Air Defences (SEAD) is a role in which specialized weapons and tactics tend to play a particularly important part. Some surface-to-air systems have inherent weaknesses: they are finite and normally have flanks, they are orientated along the expected threat axis, they are rarely equally strong throughout their width and depth, and they are fixed or relatively immobile. Others - deployed in zones or areas to provide all round defence - have fewer weaknesses. SEAD tactics are designed to exploit any potential weaknesses to the full.

2.(U) It was with an appreciation of the importance of SEAD as part of any future RAF air campaign that, in 1977, AST 1228 was introduced. The requirement as specified by AST 1228 was for a suppression weapon to support Tornado GR1 strikes within the Central Region environment. Initial competition was between BAe ALARM (a new weapon) and Texas Instruments HARM (a proven system). In 1983 the contract was awarded to BAe ALARM. Due for an ISD of 1992, ALARM was accepted into service at very short notice in 1990 and immediately deployed to the Gulf. In 1991, the weapon system was employed operationally during the Gulf War, where over 100 missiles were fired. Following the Gulf War and Options for Change, No IX Sqn were nominated by MOD to become the first ALARM sqn, with a declaration of capability to NATO on 1 Jan 1993. Subsequently, on 1 Jan 1995, a second ALARM sqn, No 31 Sqn, was declared to NATO with a SEAD capability.

DEFINITIONS

3.(U) **Suppression of Enemy Air Defences (SEAD).** Suppression of Enemy Air Defences is that activity which neutralises, destroys or temporarily degrades enemy air defence systems in a specific area by physical attack and/or electronic warfare to enable air operations to be conducted successfully.

4.(U) **Hard Kill/Lethal Suppression.** A hard kill involves the destruction of, or severe damage to the target system or crews and causes a permanent or long term effect.

5.(U) **Soft Kill/Non-Lethal Suppression.** A soft kill occurs when an air defence system is forced to shut down for fear of a hard kill attack and, therefore, the system cannot engage the attack aircraft; the effect of a soft kill is temporary in nature.

INTENTIONALLY BLANK

CHAPTER 2 - ALARM SYSTEM DESCRIPTION

INTRODUCTION

1.(R) ALARM is the only Anti-Radiation Missile (ARM) in the RAF inventory and provides Commanders with a lethal defence suppression weapon which can be employed to attack physically the enemy air defence system; ALARM has both a hard kill and soft kill capability. ALARM is an intelligent missile which, unlike HARM, does not require specialist aircraft sensors to locate the target Air Defence system. Moreover, HARM uses the main beam of a system's radiation to home to that system, whereas the ALARM seeker detects radiation from the sidelobes of the radar and uses these emissions to home. Furthermore, it uses these sidelobe emissions to update the position of the target in the missile computer, so that in the event of radar switch-off (either procedural or reactive) the missile will navigate to the up-dated target position and attack it; this is known as "blind homing".

MISSILE PROFILE

2.(S) The basic ALARM delivery profile may be from either a low level or medium level penetration to a launch point; the missile may be fired from heights down to 100 ft AGL. Launch is achieved using a boost motor, which burns for approximately 0.7 secs, the missile then enters a steep climb powered by a sustain motor which burns for approximately 52 secs. Thereafter the missile coasts, the point at which the missile commences to search for targets varies from mode to mode, but generally is shortly after the missile reaches the apogee of its trajectory.

3.(S) Target identification is achieved by a software controlled scanning receiver which operates in the 2 to 18 GHz frequency range using a statistical pulse train identification algorithm. Target prioritization, selection and homing are controlled by the Mission Control Unit (MCU). Having committed to a target, ALARM enters its terminal attack phase and attempts to approach the target within 20 degrees of the vertical. A laser fuse detonates the warhead at a pre-programmed height dependent on the system being attacked. The warhead which comprises 3000 x 6mm tungsten alloy fragments detonates in a 40 degree annular pattern. If the missile fails to acquire a target the warhead will detonate at a pre-determined reversionary height.

MODES OF OPERATION

4(R) ALARM has 5 modes of operation which are selectable by the user at the missile programming stage. The 5 modes are:

a. Dual Mode

b. Loiter Mode

c. Direct Mode

d. Corridor Suppression (CS) Mode

e. Universal Mode

The Dual, Loiter and Direct modes are known as Target of Known Location (TKL) modes and require accurate information of target location (within 1 nm) to achieve reasonable P_ks. The CS and Universal modes are Area Suppression modes, where the missile searches for selected systems within an area known as the missile footprint.

5.(S) A brief description of each mode follows:

a. **Dual Mode.** From a low level launch the missile climbs before entering a glide phase during which the seeker searches for targets located at or close to the programmed position. The search continues until a valid target is acquired (in which case a direct attack will be made), or the programmed position is about to leave the missile field of view (in which case a parachute will be deployed). If during this loiter phase no target is detected within 150 secs the parachute is jettisoned and an attack on the programmed position is carried out. If launched at maximum range the first impact could occur some 2 mins 30 secs after launch, with a last impact of 5 mins 10 secs, giving a theoretical period of coverage for this attack of 2 mins 40 secs. If launched at minimum range the coverage reduces to 2 mins 30 secs with a possible first impact at 2 mins 10 secs and a last impact at 4 mins 40 secs.

b. **Loiter Mode.** During a Loiter Mode attack there is no search for targets during the glide phase and the seeker is not activated until parachute deployment. The missile then acts in the same way as described at sub para a above. If launched at maximum range the first impact could occur some 3 mins after launch with a last impact time of 5 mins 20 secs, giving a theoretical period of coverage for this attack of 2 mins 20 secs. If launched at minimum range the coverage becomes 2 mins 10 secs with a possible first impact at 2 mins 40 secs and a last impact at 4 mins 50 secs.

c. **Direct Mode.** In the Direct Mode the missile trajectory is optimised for maximum ground speed. The missile searches for a target at or close to the programmed position. If a target is acquired the missile will home to it, if not the missile navigates to the programmed position and carries out an attack on that. If fired at maximum range impact should occur some 2 mins 50 secs after launch, if, however, the missile is launched at minimum range impact should occur about 1 min 30 secs after launch.

d. **CS Mode.** In the CS Mode the missile climbs to height, the seeker is activated and the missile enters a glide phase. Flying a pre-programmed flightpath the missile searches for emissions which match those programmed into the missile. If a valid system is detected the missile will home and attack that system. If no target is acquired the missile navigates to an imaginary target located 28 nm from the launch point and carries out an attack at that position.

e. **Universal Mode.** The Universal Mode is optimised for a medium level launch thus extending the range of the missile. In all other respects it is identical to the CS Mode.

6.(R) Whereas all the modes can be used against point targets, only the AS modes (CS and Universal) can be used to search and suppress an area of interest. This concept may be employed against mobile Air Defence systems whose positions can change rapidly. Available only in the 5, 7 or 9 missile fit, an area of approximately 20 nm by 46 nm can be searched and selected systems within that area attacked. Procedures have been introduced to minimise the risk of more than one missile attacking the same target; however, due to the nature of the missile this potential overkill cannot be eradicated. It must be stressed that a "blind homing" capability will not exist if the missile is used in this way, nor can the missile attack a system which is not emitting. Therefore, it is unrealistic to consider an area to be truly sanitised by an ALARM package launched in this manner.

TARGET CLASSIFICATION

7.(S) In all modes, target systems can be allocated priorities to ensure that the optimum coverage of the target area is achieved. The systems against which ALARM has a capability are grouped in three classes:

a. **Class 1.** ALARM may be expected to attack effectively in any operating mode.

b. **Class 2.** ALARM may be expected to attack effectively in TKL modes.

c. **Class 3.** Very difficult for ALARM to attack. Loiter or Direct mode is recommended.

TACTICAL PHILOSOPHY

8.(R) The philosophy behind SEAD is that ARMs should be ready to attack enemy air defence systems before those systems can complete a successful engagement on the attack aircraft and that ARMs should continue to pose a threat to any air defence system until the last of the attack aircraft has departed the engagement zone. It is highly unlikely that ALARM assets will be tasked on stand-alone missions, rather, it is anticipated that they will be tasked in support of attack packages. Therefore, ALARM aircraft will need to be in a position to provide protection for the attack package from the time that the first attack aircraft enters the Missile Engagement Zone (MEZ) until the last attack aircraft leaves the MEZ. It is this factor more than any other that has determined the various tactics which can be used in the employment of ALARM.

INTENTIONALLY BLANK

CHAPTER 3 - ALARM TACTICS

INTRODUCTION

1.(R) The original concept of operation for ALARM envisaged a Central Region conflict and much store was placed on the AS modes to deal with the mobile SAM systems protecting the first tactical echelon. The concept of clearing sanitised corridors through the FLOT required up to 70 or 80 missiles to suppress a corridor 30 km wide and up to 70 km long. Recent world-wide geo-political changes have made this an extremely unlikely scenario. It has, therefore, been necessary to adopt a more flexible approach to the likely employment of ALARM.

TACTICS - GENERAL

2.(S) **Intelligence.** One of the critical aspects of ALARM operation is intelligence support and ELINT. Accurate positional information on target position and ideal fuzing height against the target system are vital if ALARM is to be employed effectively in the TKL modes. Ideally, this information will be provided to the ALARM operator at the planning stage and as part of the tasking process; however, procedures have been established whereby this information can be obtained whilst the ALARM assets are airborne and this is covered later in this Chapter.

ATTACK PACKAGE CO-ORDINATION

3.(R) Close liaison between the attack package commander and the ALARM package leader is required to co-ordinate ALARM effectively as a SEAD asset within or in support of an attack package. The following information is required by the ALARM package leader:

a. The threats to be covered, including priorities if more than one threat.

b. The cover required: ingress, egress, target inbound, target outbound or a combination. This should be prioritised, it is still better to avoid a threat on the ingress or egress if at all possible.

c. The time of entry of the first attack element into the threat MEZ and the time of exit of the last attack element from the threat MEZ.

d. The attack package routing to and from the target, highlighting any MEZs entered.

e. Details of any other SEAD assets supporting the mission (HARM, SOJ, CIJ etc).

The ALARM package leader will provide the following information to the attack package commander:

f. Whether ALARM can handle the task.

g. The optimum mode or modes of operation of ALARM for the particular task.

h. The coverage available from the ALARM package.

i. ALARM package routing and deconfliction.

j. Advice on how best to employ any other SEAD assets.

Ideally co-ordination between the attack package commander and the ALARM package leader should take place face-to-face; if this is not possible the telephone tasking matrix at Annex A should be used.

AIRCRAFT CONFIGURATION

4.(S) ALARM capable Tornado GR1s can carry up to 9 ALARM (subject to the availability of stub pylons). Without stub pylons the maximum load is 5 missiles

(3 underfuselage and 2 underwing (in place of fuel tanks)), the radius of action in this fit is limited. A more common load would be 3 ALARM underfuselage. Stub pylons increase the maximum load to 9 missiles, however, as this precludes the carriage of underwing fuel tanks, the radius of action in this fit is limited, furthermore no Air-to-Air missiles can be carried. The 7 missile fit increases the radius of action but again no Air-to-Air missiles can be carried. The 5 missile fit allows all missile modes to be employed and allows the carriage of fuel tanks and Air-to-Air missiles.

ALARM SUPPORT FOR ATTACK PACKAGES

4.(R) The complexity of the ALARM mission is proportional to the size of the attack package and the severity of the threat. ALARM support for small packages is a relatively straightforward task; however the MEZ suppression times required by large packages require the employment of a more complex ALARM tactic.

5.(S) **ALARM Support for a Small Package.** Although the complexity of the mission is dependent upon the severity of the threat, support for a small package is probably the most straightforward of all ALARM missions. Unless a particularly long MEZ suppression time is required, the task can most probably be achieved by a single ALARM attack by a pair of aircraft. Generally, for an attack of this nature, the ALARM aircraft will route ahead of the attack package to be in a position to fire when the first attack aircraft enters the MEZ; however, in order to benefit from any package protection, it is desirable and tactically sound to integrate the ALARM aircraft into the main attack package for as long as possible before pushing them ahead to prosecute their attack. The ALARM package will attempt wherever possible to attack on a totally different axis to the attack package. This tactic achieves a maximum MEZ suppression time of 3.5 minutes per aircraft. Small extensions to MEZ suppression times can be achieved by staggering the firings of the lead and following ALARM aircraft or by rippling the firings of each aircraft.

6.(S) **ALARM Support for Larger Packages.** To cater for the extended MEZ suppression times required by large attack packages the following tactics for medium or low level have been developed:

a. **ALARM CAP.** The basic fighting element of the ALARM CAP is a pair of ALARM aircraft. In VMC, these aircraft fly in Battle formation and one aircraft fires 2 missiles at each emitter. By firing one missile in Direct mode and the other in Loiter mode, a MEZ suppression time of 3.5 minutes is achieved. The pair then fly mutually supporting Battle turns to re-attack along the same axis 3.5 minutes later. The second aircraft carries out this attack, following identical procedures to the initial attack. This procedure is followed until all missiles are expended or the attack package has departed the MEZ. In IMC, the ALARM aircraft fly in 3.5 minute trail and fly the CAP to achieve 7 minute re-attacks. The number of re-attacks is dependent upon the number of missiles carried and the number of threat emitters to be suppressed. The CAP may be flown at any altitude depending on the air and ground threat. COMAO has shown that careful deconfliction is required in the target area. This is achievable by careful co-ordination between all aircraft. Alternatively, an ALARM Box can be established. This is similar in principle to the ROZ Box employed by Wild Weasel aircraft, namely, during SEAD operations, ALARM aircraft will remain inside the ALARM Box and attack aircraft will remain outside it. To maximise tactical flexibility, the box is designated in 3-dimensions, with altitude restrictions allowing possible over-or under-flight by attack or support aircraft. In a high air threat, it is anticipated that high value assets such as SEAD aircraft will be allocated dedicated fighter support; this support would be used to accompany the SEAD aircraft to the ALARM Box and to fly CAP overhead during SEAD operations.

b. **Off-Axis Re-attack.** Aircraft flying ALARM CAPs have mutual cross cover from Battle formation; however, repeated overflight of the same ground track makes them potentially vulnerable to air and ground defences in a high threat environment. The Off-Axis Re-attack caters for such a scenario. Similar in concept to the ALARM CAP, in that it extends possible MEZ suppression time considerably, the Off-Axis Re-attack involves ALARM aircraft repositioning after the initial firing to re-attack, 3.5 minutes later, on a completely different line of attack. Although this tactic avoids repeated overflight, it increases the complexity of target area deconfliction.

STAND-ALONE MISSIONS AND ARMED SEAD

7.(S) ALARM has both a hard and soft kill capability and in the majority of cases the effect will be the same - preventing the enemy air defence system from engaging the attack package. However, in certain scenarios it may not be sufficient for SEAD aircraft to achieve soft kills on their targets, therefore, the concept of Tornado GR1 Armed SEAD has been developed. The concept relies on the carriage of 2 ALARM on stub pylons underwing and appropriate conventional weapons (impact or airburst 1000 lb bombs, LGBs, BL755 or CBU 87) underfuselage. The 2 ALARM are launched in the Direct and Loiter modes to provide MEZ suppression for the firing aircraft which, post-launch, beam the threat to remain outside the MEZ. The Direct mode missile impacts first and should cause either a hard or soft kill. The MEZ is now effectively suppressed because if the system transmits following the impact of the Direct mode missile, the Loiter missile which will be suspended in a parachute above the emitter has an opportunity to engage the system. The effective suppression of the system allows the ALARM aircraft to follow the ALARM attack with a conventional attack on the system position using whichever weapon is carried underfuselage. The provision of accurate positional information on the location of the target system is particularly important if ALARM is to be employed in this manner.

ON CALL TASKING

8.(S) To employ ALARM in its most accurate and effective modes the position of the target systems must be known to within approximately 1 nm. The requirement for accurate positional information on the location of the enemy air defence systems is one of the major limitations in the employment of SEAD. If this information is not known, then the AS modes, with their large footprints, are the only usable ALARM options. Unless the ROE for a particular scenario allows for the possibility of collateral damage within a certain area, the use of ALARM may be constrained to the TKL modes. As Tornado GR1 is unable to establish the position of target emitters, external agencies must be used to define the target emitter positions with sufficient accuracy to use the TKL modes. If this information cannot be provided by ground intelligence sources, in which case conventional tasking could be used, then On Call Tasking with co-operative systems capable of defining target emitter locations can be used. The concept of Sniper Ops uses the accurate positional information provided by another aircraft's Emitter Locator System (ELS) to program the ALARM whilst airborne. The concept has been practised with ECR Tornados and a read across to the Wild Weasel APR-38 ELS and other ELINT platforms is obvious. Before flight the ALARMs are programmed in the CS mode with the most accurate target co-ordinates available. In flight the ELS aircraft pinpoints the accurate target position. The co-ordinates of this position are passed in coded form by VHF/UHF comms to the ALARM aircraft. The target position and delivery mode of the missile are then reprogrammed by the ALARM aircraft navigator via the aircraft TV-Tabs and the missiles are launched in a suitable TKL mode. The advantages of this tactic over autonomous operation are twofold. Firstly, the use of TKL mode reduces the risk of collateral damage whilst increasing the P_k of the missile and of extending MEZ suppression time if a parachute mode is employed. Secondly, if the target radars are not emitting the ELS aircraft can abort the attack.

POST FIRING MANOEUVRE

9.(S) In an attempt to stimulate the target radar into emitting, ALARM aircraft can continue towards the threat radar position following launch. This tactic known as "Tickling" can be used to increase the chances of a hard kill and to attract the system operator's attention away from the line of attack of the attack package. The decision to use such a tactic must be based upon the likelihood of a successful engagement on the ALARM aircraft by the target system versus the need for a hard kill on the target. This tactic should always be flown as a pair to give mutual ECM pod coverage, RHWR information and missile launch warnings.

CODEWORDS

10.(R) The following codewords are used during ALARM operations:

a. "MAGNUM" - ALARM launch.

b. "ANVIL" - ALARM aircraft will launch in degraded mode.

c. "HAMMER" - ALARM aircraft will launch in degraded mode and requires shepherding to launch point (the shepherd aircraft will be another member of the ALARM package).

ANNEX A TO
CHAPTER 3, SECTION 10 OF
TORNADO GR1 TACTICS MANUAL

SEAD/ALARM TELEPHONE TASKING MATRIX

1. Date of Exercise:

2. Participating formations:

AC TYPE , C/S NUMBER, TEL No, ROLE, TOT, AC SPACING, ATTACK TYPE

a. ....

b. ....

c. ....

d. ....

3. Target emitter details:

SAM/AAA SYSTEM, RADAR, POSITION, PRIORITY

a. ....

b. ....

c. ....

d. ....

4. Package routing and TRPs:

....

....

....

....

5. Frequencies:

....

....

6. MEZ Suppression times:

a. ....

b. ....

c. ....

d. ....

7. ALARM BOX position or launch points:

....

....

ALARM BOX height or height at launch:

....

8. Overall Mission Cdr:

.... Tel No: ....

9. ALARM Cdr:

.... Tel No: ....

Section 11

Reconnaissance

Chapter 1 Reconnaisance - General

2 Tactical Employment of TIRRS

SECTION 11 - TABLE OF CONTENTS

CHAPTER 1 - RECONNAISSANCE - GENERAL

Page Number
(within the Chapter)

INTRODUCTION 1

DEFINITIONS 1
  Pinpoint Target 1
  Strip Search 1
  Line Search 1
  Area Search 1

ANNEX A: RESOLUTION/RECOGNITION RANGE CROSS SECTION A1

CHAPTER 2 - TACTICAL EMPLOYMENT OF TIRRS

GENERAL 1
  Sensors 1
  Stand Off 1
    SLIR 1
    IRLS 1

PLANNING 1
  Tasking 2
  Timing Considerations 2
  TOT 2
  Map Preparation 2
  Speeds 2

SPECIFIC TARGET COVERAGE 2
  Pinpoint Targets 2
  Strip and Line Searches 2
  Area Searches 2
  Area Targets 2
  Electronics 2

PAIRS RECONNAISSANCE 3

RECCE ATTACK INTERFACE (RAI) 3

ARMED RECONNAISSANCE 3

EXECUTION 3
  Pre-flight 3

PINPOINT TARGETS 3

LINE SEARCHES 4

STRIP SEARCHES 4

AREA SEARCH 4

EXPLOITATION 4

PART C 4

IN-FLIGHT REPORTING PROCEDURES 5
  General 5
  Radios 5
  Format 5
  Multiple Targets 5

POST FLIGHT 5
  Engine Shutdown/Tape Download 5

ANNEX A: EXTENT OF RESOLUTION GAP AT VARYING HEIGHTS AGAINST 2.7M TARGET A1

ANNEX B: RECONNAISSANCE ATM DECODE B1

ANNEX C: VELOCITY/HEIGHT GRAPH C1

ANNEX D: STRIP AND LINE SEARCH TECHNIQUES D1

ANNEX E: RECCE ATTACK INTERFACE E1
  Appendix 1. Position Reporting Reference Systems E1-1

ANNEX F: RECONNAISSANCE STEERING LAWS F1

ANNEX G: PART C G1

CHAPTER 1 - RECONNAISSANCE - GENERAL

INTRODUCTION

1.(U) Although long-distance stand-off reconnaissance systems can now provide surveillance and intelligence on areas well inside enemy territory, tactical reconnaissance aircraft are still required to provide detailed and positive target location, identification and intelligence information. The Tornado Reconnaissance System (TRS) is a 24 hr, near-all-weather capable system that has been designed to meet current day/night reconnaissance tasking requirements and to reduce reconnaissance response times. The TRS was developed to meet the requirements of SR(A) 1363 which specified, in addition to a multi-function cockpit display of sensor imagery, the following main points:

a. Optimisation for flight at 200 ft and 600 kn.

b. Have minimal effect on the carriage and release of external stores.

c. Ability to function by day or night and in poor weather.

d. Sufficient resolution to enable the recognition of MBTs out to 1.5 kms from the aircraft.

e. Provide horizon-to-horizon coverage.

f. Produce imagery in a format suitable for data link transmission.

2.(U) Infra-Red Linescan (IRLS) was a proven system and appeared to be the natural choice to fulfil the majority of the requirements. However, the need to produce high resolution imagery capable of permitting AFV recognition out to 1.5 km from an aircraft flying at 200 ft highlighted a problem inherent in all IRLS systems. At high oblique angles, any IRLS will suffer from severe scaling problems which will require a resolution 20 times greater at the extremes than that required vertically beneath the aircraft; this effectively limits the achieved semi-FOV to 80°. As a result, the IRLS was supplemented by 2 Sideways Looking Infra-Red (SLIR) sensors (1 either side of the aircraft) to provide coverage of the problem sectors. A diagram of sensor coverage is at Annex A.

3.(U) The tactics required to exploit the Tornado reconnaissance system to the maximum have yet to be fully determined and therefore the procedures laid down in this Section may change as more experience is gained with the system.

DEFINITIONS

4.(U) **Pinpoint Target**. For the reconnaissance of a single co-ordinate location, full sensor coverage is required and should normally provide a reasonable area surrounding the location to allow for target position and minor plotting errors.

5.(U) **Strip Search**. Reconnaissance along a straight line between 2 given reference points up to 10nm apart requires that sensor coverage begins at the start and end points, and significant sightings en-route. Continuous IR coverage is desirable.

6.(U) **Line Search**. Line search is the reconnaissance along a specific line of communications, such as a road, railway or waterway between 2 given reference points up to 30 nm long to detect mobile targets and activities in general. Sensor coverage is required of the start and end points and significant sightings en-route. Continuous IR coverage is desirable.

7.(U) **Area Search**. Reconnaissance of a defined area, not larger than 12 square nm, to locate known or suspected activity is defined as area search. Sensor coverage of detected activity is requested, however visual reconnaissance is the primary detection means. Continuous IR coverage is desirable.

INTENTIONALLY BLANK

RESOLUTION/RECOGNITION RANGE CROSS SECTION

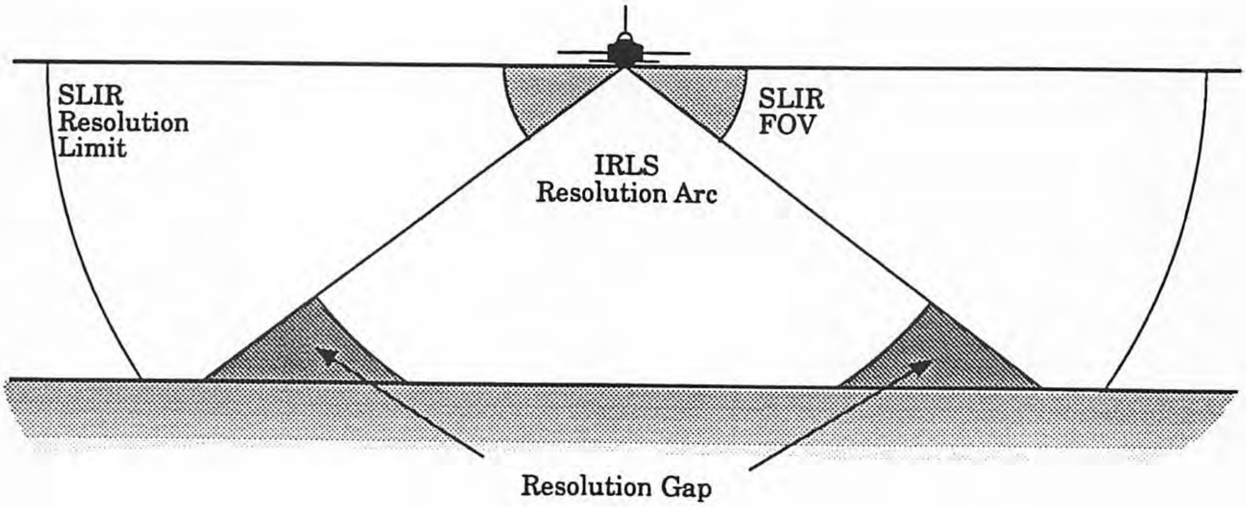


Figure 11-1A-1 (U) - Schematic Resolution Diagram

(NOT TO SCALE)

INTENTIONALLY BLANK

CHAPTER 2 - TACTICAL EMPLOYMENT OF TIRRS

GENERAL

1.(U) To minimise obscuration and IR attenuation, caused by atmospheric water, direct over-flight will obtain the best imagery. Obscuration will become worse at operational flying heights. A little stand-off may be required to give a 3-dimensional view of the target, and to allow for visual reconnaissance.

2.(R) **Sensors.** The IRLS should be regarded as the prime sensor, with the SLIRs as "fill-in" sensors. However, for specific targets the SLIRs may be the best option; e.g. targets on a steep hill side, those having a large vertical extent, or where an oblique view is required. With the SLIR FOV marked on the canopy pilots are able to point the SLIR accurately without the navigator being heads-in, provided that the SLIR is locked. Pilots should not allow the angle of bank to exceed 30 degrees immediately prior to, or over the target, as coverage will be unacceptably degraded or lost. Should the IRLS fail then increasing the stand off distance to 600m, or in VMC pointing the SLIR, will help to obtain a good SLIR image of the target.

3.(R) **Stand Off.** The resolution of the human eye in daylight exceeds that of any of the sensors. Visual recognition may provide valuable additional information, aid the exploitation of the imagery and provide a fall-back in the event of a TIRRS failure. To give the pilot a good view, and thus aiding visual identification whilst still getting optimum coverage on the IRLS, a small stand-off is generally desirable.

a. **SLIR.** A graph of SLIR and IRLS coverage against a 2.7m (MBT size) target is at Annex A. However, a good rule of thumb for the position of the bottom edge of the SLIR FOV, on flat ground, is as follows:

Bottom of SLIR FOV from the aircraft centre-line (in metres) =
2 x aircraft height (in feet).

Example: When the aircraft is at 250 ft the bottom of the SLIR FOV touches the ground 425 metres from the aircraft centreline.

b. **IRLS.** A Rule of Thumb to obtain the IRLS stand-off distances for optimum sensor and visual cover is shown in Table 11-2-1. This rule applies to targets on level terrain. If the target has a significant vertical extent you must fly at or above the total target height to get it on the IRLS.

Aircraft Height (feet)	Optimum stand-off (metres)
500	100 - 200
250	75 - 150
200	60 - 100
150	50 - 100

Table 11-2-1(R) - Rule of Thumb Stand-off Distances

PLANNING

4.(R) Reconnaissance follows the normal attack rules, except for the minor points detailed below:

a. Pre-target plan and height fixes should be planned and accepted to ensure a good MC position.

b. To ensure track capture by the reconnaissance steering, targets should always be planned with a 10 nm straight run in whenever possible, but with an absolute minimum of 5 nm.

c. It is preferable to have the IP as an all-sensor offset.

d. Prior to the target, with a good mark on one or more offset(s) the ROL should be accepted so that the MC has the most accurate position available (positional data recorded on tape is not updated until correction is accepted). Consideration should be made as to whether to degrade to IN mode and thus accept 100% of the fix update if there is a large error.

e. When a stand-off distance is being used, reflect this in the track line drawn on the 1:50,000 map so that in the event of flying a reversionary IP to Target run there is a realistic line to follow to achieve the desired stand-off.

f. If the sensors are pointed at, or too near to the sun immediately prior to the target the imagery will be severely degraded.

g. Do not exceed an AOB of 30 degrees when approaching the target.

5.(U) **Tasking**. Tasking will generally be by an Air Task Message (ATM). The ATM can be de-coded using ATP 47 dated Jun 86. An example of the pertinent points of an ATM de-coded is at Annex B.

6.(R) **Timing Considerations**. Unless an ASAP task is received, the allocated planning times for a reconnaissance sortie in the Central Region are:

a. **Day VMC** - 40 minutes for the first target, and 10 minutes for each additional target.

b. **Night and IMC** - 60 minutes for the first target, and 20 minutes for each additional target.

c. **Pairs and AAR**. If planning for a pair a further 20 minutes is available. Another 30 minutes is available if AAR is required.

7.(R) **TOT**. Mission TOT applies to the highest priority target. If all the specified targets are of equal priority the TOT applies to the first listed target.

8.(U) **Map Preparation**. The 1:500,000 chart should be annotated in accordance with the attack SOPs, but also include recorder-on points. For operational sorties the turning point closest to the recorder-on point should be made an auto event.

9.(U) **Speeds**. Speeds should be in accordance with COMAAFCE Supplan 35001M. Crews should aim to increase speed to cross the FLOT, and fly at best obtainable max dry power speeds on the IP to target runs (Values from the velocity/height graph at Annex C should not be exceeded). For IMC/night peacetime planning do not plan to exceed the TF maximum speeds.

SPECIFIC TARGET COVERAGE

10.(U) **Pinpoint Targets**. The target location is usually given as a UTM which for a 6 figure UTM is the bottom left hand corner of a 100 metre square. Targets such as large rail yards, airfields, SAM sites, storage areas and rear assembly areas should be treated as area targets.

11.(U) **Strip and Line Searches**. Strip searches are always a straight line. A line search aims to provide the best coverage possible of a curved line feature. Further details are at Annex D.

12.(U) **Area Searches**. Narrow area searches can be flown as a strip search. Large area searches will either require 2 aircraft, or will have to be flown in several strips with a suitable time interval between passes within the TOT bracket.

13.(U) **Area Targets**. Most area targets such as airfields, SAM sites, storage areas and rear assembly areas could be tasked for either pre- or post-strike reconnaissance. Direct over-flight will give the best sensor coverage and minimise obscuration. The SLIRs will be vital to ensure full coverage of the target extremities. Large, high priority targets may require 2 aircraft, or several passes, to obtain complete coverage. For large targets any specific points of reconnaissance interest should be included on the ATM. Target planning should ensure optimum coverage of these points while still retaining good general target coverage.

14.(U) **Electronics**. For electronic installations it is desirable to have some stand-off as they are generally vertically orientated. This stand-off depends on the type, size and location of the target. For targets likely to be camouflaged, mobile or heavily obscured, direct over-flight will be necessary.

PAIRS RECONNAISSANCE

15.(U) Route planning and flying for a pairs reconnaissance mission is as for a pairs attack mission. Most realistic pairs reconnaissance missions will be for large, high value targets. Plan to give maximum coverage of these targets, but have a reversionary plan for single aircraft cover. A timing split over the target may be necessary for de-confliction, but maximum TOT compression is usually desirable for survivability. If the target is relatively small, plan individual target runs to get different perspectives.

RECCE ATTACK INTERFACE (RAI)

16.(U) RAI is a tactical procedure to enhance the success of attack forces primarily against mobile targets in a given area. It normally requires a reconnaissance aircraft to be tasked to the area in order to update and validate the position and nature of enemy forces, and then to pass this information to the attack force via an in-flight report.

17.(U) Normally there will not be sufficient reconnaissance assets available to allow concentrated RAI. A logical substitute would be attack-attack interface (AAI), where a flying unit uses its own aircraft to provide the "eyes" for the remaining attack package. Further details of RAI are at Annex E, and in AIRCENT Manual 80-6.

ARMED RECONNAISSANCE

18.(R) In the unlikely event of bombs being carried on war recce missions, crews must remember that if a weapon package is selected, recce stand-off is inhibited and the steering provided is direct to target.

EXECUTION

19.(R) **Pre-Flight.** Crews should take the following equipment to the aircraft:

a. TIRRS debrief form.

b. Plastic bag.

c. A set of maps. Each 1:50,000 map should have a target report attached to it.

d. A CVR tape.

e. A blank RECCEXREP form.

PINPOINT TARGETS

20.(R) Similar to attack flying the MC position must be kept as accurate as possible throughout the route. Recce steering i.e. track capture, stand-off, etc. can only be accessed in F/A, without a weapon package selected. F/A itself may only be selected when steering towards the Point Of Interest (POI), unless it has been designated X, Y or Z. The recce steering track capture laws, illustrated at Annex F, are not as robust as those for the JP 233, therefore it is important to select F/A only when pointing at the target. If F/A needs to be taken early for offset marking, the pilot must be prepared to take control of the aircraft and manually steer towards the target if recce steering is not working.

21.(R) Before the recce target run the video recorders should be selected to ON if not already recording and optimum GAMMA setting selected on RCP. RCN should be selected on the LH TV TAB to display the best format for initial exploitation based on the planned recce pass. At night this should be left to CENT while VMC D/R ROL or SLIR could be selected. The CVR should be selected to MAN and ON and in VMC this is a good time to note the TARWI.

22.(R) All kit recce target runs, be they Pinpoints, Line Searches or Strip Searches need accurate marking of offsets whether it is in PH 1, 2 or OTO. Since any target position gained from recce exploitation uses the MC present position as its basis, it is important that, if possible, the navigator accepts any plan error and then re-marks the offset before target flypast. If the errors are large a double accept may be necessary or even degradation to IN mode. The navigator must radar mark the offset/target to obtain the most accurate position and the pilot then advises when visual with the target. In day/VMC the pilot can then position the aircraft for the planned stand-off or advise any changes to the plan to allow the navigator to alter the display on the TV TAB as required. The pilot should then describe the target for recording on the CVR. The navigator should also try to acquire the target visually if stand-off allows. However, with the pilot 'target fixated' look-out must remain a high priority in the target area. If not visual with the target the navigator must use either a call from the pilot, TTG on the RH TV TAB or visually map read on the 50,000 map to allow him to FREEZE the TV TAB target image on flypast for initial exploitation.

23.(R) Once away from the high threat area the target may be viewed for further airborne exploitation if time/threat allows. The initial FREEZE picture can be used for a cursory overview however for full exploitation the FIND function must be used together with TARGET for positional information.

LINE SEARCHES

24.(R) A Line Search has at least two designated recce points; a Line Start (LS) and a Line End (LE). The actions involved in getting to the LS are the same as those above for a Pinpoint target, however, it is even more important to arrive at the LS extremely accurately on heading and also at the correct GROUNDSPEED (GS). Since IMC line search can be planned as a complex series of turns any error in heading, position or GS can result in very limited coverage of the line. Recce steering will hold the aircraft straight and level for 1 mile either side of the LS. Remember you can only access recce steering when actually steering to the POI and selection of TARGET or OFFSET will dump the previous updates, unless accepted; therefore if target bars are required at the LE, or recce steering is needed within the line search to a POI to allow further positional update, then the error line should be accepted prior to re-selecting F/A or TGT/OFFSET.

25.(R) On the line itself in VMC the crew can allocate sides to look out or the pilot can look close to the line, the navigator further away. Since in VMC the pilot is 'navigating' along the line, the navigator's job is also one of look out. Commentary for the CVR is essential and when a recce POI is sighted the navigator must note the real time of flypast and distance to next waypoint, to allow him to FIND it on tape playback for exploitation and plot it on the 50,000 map. The navigator should have CENT selected for display during the line search; only one recce POI can be FROZEN for initial exploitation. On IMC/night line searches the pilot's more important jobs are to monitor the steering and to maintain the GS to stay on the planned line. Line Searches are covered in more detail at Annex B.

STRIP SEARCHES

26.(R) There are 2 methods of planning a Strip Search (SS). If the SS end is a designated target and the start point an offset, then the strip is flown exactly as a pinpoint with the pilot making sure the offset cross and target bars are aligned accurately to cover the strip. If the SS has a LS and LE then for accuracy, once past the 1 mile point steering to LE, target may be re-selected (after accepting the error line) to give target bars in the HUD. Strip Searches are covered in more detail at Annex B. Reporting on any recce targets on the strip follow the same guidelines as detailed for Line Searches.

AREA SEARCH

27.(R) Area searches are just a series of SSs to cover an area. The MC must be kept accurate with fixes or a number of target runs, to allow the position of any recce targets to be obtained using the TARGET function. IN mode can be selected if the MC Kalman filter is unhappy with constant positional update. However, be aware that a typical IN drift rate of 1 nm/hr equates to 100 ft/min.

EXPLOITATION

28.(R) Exploitation using the FIND facility should be done in a low threat area as soon as possible after target over-flight. The Nav tapes can be used, however for speed of FINDING the GND REPLAY facility can be used after the EDIT is completed and the RCP switched off and back on again.

PART C

29.(R) A correctly completed Part C, as shown at Annex G, enables the Photographic Interpreters (PIs) to find and exploit target imagery by the most expeditious means. The Part C is also an *aide-memoire* for the crew during planning and is to be used on every TIRRS mission; the completed Part C is to be handed in with maps and CVR tape at VCR tape download.

IN-FLIGHT REPORTING PROCEDURES

30.(R) **General.** Tasking will require that an in-flight report (IFREP) is passed on all tasked targets. Aim to IFREP as soon as possible after target over-flight, when clear of the immediate threat. Survival should not be jeopardised by working "heads in" on a "find" whilst still in a high threat environment.

31.(R) **Radios.** IFREPs should be passed clearly and slowly with transmission pre-empted by a warning call of " Standby for IFREP". The IFREP can be passed on HF (when cleared) or V/UHF. V/UHF has quite a short range and crews should use a ground or airborne relay stations if available. For training in UK airspace the IFREP can be passed to AWACS, callsign "Magic", on frequency 364.2 MHz. When using "Magic" to relay, crews should state the destination of the IFREP; eg. Marham Ext 7120.

32.(R) **Format.** The following format will be used when reporting a reconnaissance target:

a. **Alpha (Target Number).** Pass the target task number, never report "as briefed". For line and strip searches use the Line Thrust System.

b. **Bravo (TOT).** The TOT is to be passed in Zulu. If the target has not been successfully covered use the following coded reasons:

(1) Zulu - weather.

(2) Papa - other reason.

c. **Charlie (Target Details).** Items C1 to C4, as laid down in the STANAGS, are to be reported on.

d. **TARWI.** Always pass a TARWI for each target. Whatever the letter codes passed, always include X, Y or Z.

e. **Intelligence Information.** After the TARWI for the last target include any information which could be of vital importance to Intelligence, and which will eventually be included in the RECCEXREP under para DELTA. Crews must be aware of the problems of passing the positions of "classified" targets in the clear over the radio. Where possible the line thrust system, or bearing and distance from a pinpoint target should be used. Some items which are under this category are shown below:

(1) Nuclear Missiles (Pass **ASAP** at any time).

(2) Interceptions on the friendly side of the FLOT.

(3) Unexpected concentration of armour.

(4) EW/Jamming.

f. **En Route Weather.** If the weather en-route merits special mention, and has not been included in the letter designation of previous TARWIs, it should be passed at this stage.

g. **IFREP Example:**

Mission 2T803 In Flight Report
Alpha 803
Bravo 1020
Charlie 1 .....)
Charlie 2 .....) As detailed on the
Charlie 3 .....) STANAG cards
Charlie 4 .....)
TARWI 0081X
Engagement by Fulcrum at
53 North, 630 East at 1025 2T803
In Flight report ends.

33.(R) **Multiple Targets.** When more than one IFREP is to be transmitted, say "Standby" between each report, and pause for 5 seconds before continuing.

POST-FLIGHT

34.(R) **Engine Shutdown/Tape Down Load.** Engine off time (EOT) or tape down load time (TDT), whichever is the earliest, (Echo Time) should be passed to ops. Echo time should be recorded on the TIRRS debrief form. After the reconnaissance video tapes have been down-loaded the following information, inside a plastic bag, is to be handed to the RIC assistant:

a. A completed and legible TIRRS debrief form. This should include any system faults.

b. A complete set of maps (all target maps and a 1:500,000 low flying chart). Each 1:50,000 map should have a completed target report attached to it.

c. The CVR tape with the real-time recordings of each target.

EXTENT OF RESOLUTION GAP AT VARYING HEIGHTS AGAINST A 2.7m TARGET

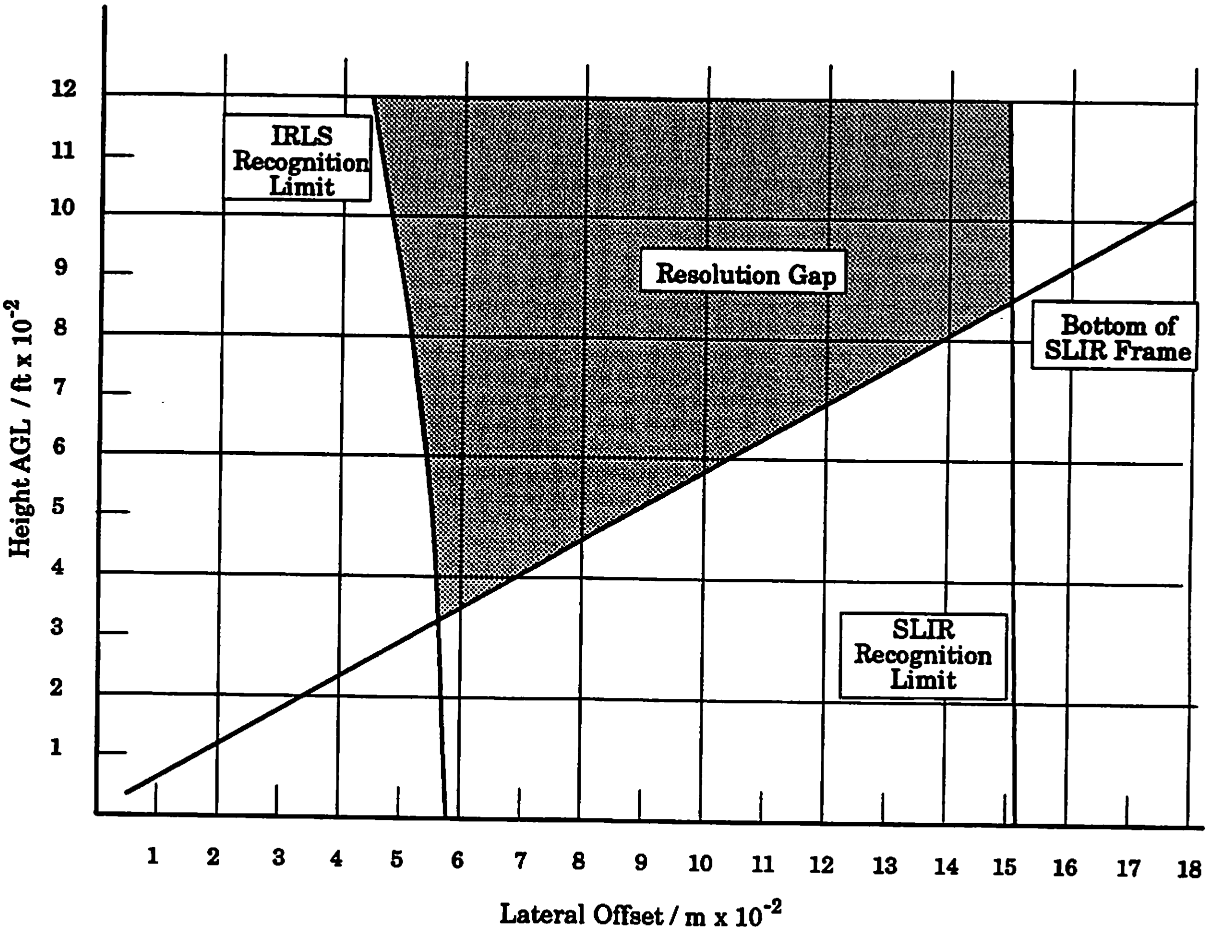


Figure 11-2A-1 (C) - Graph of Resolution v Height (AGL)

INTENTIONALLY BLANK

ANNEX B TO
SECTION 11, CHAPTER 2 OF
TORNADO GR1 TACTICS MANUAL

RECONNAISSANCE ATM DECODE

1.(U) ATP 47 dated Jun 86 is used to code and decode the pertinent parts of an ATM.

2.(R) **Marham ATM Example.** An example of a Marham reconnaissance ATM is given below.

```
  AGCY      : MARHAM  EX: EXA /
Q       DTGAG:  100943  ATOC:  MARHAM
A1/REQNR     : 2AW567
A2/TYMIS:  RECCE
A3/TYSEN   : A3/TECH
A4/TGTINFI : 567 NX790660 .CAT 12 A PRIO: 3
A5/TGTINF2 : 568 NT872682 .CAT 03 A PRIO: 3
A6/TGTINF3 :
A7/TGTINF4 :
B /TOT   : 101245  Z  NLT:  1011255Z
C /DELI       :
  DEL 2       :
  DEL 3       :
D/CONTDET1:
              2:
              3: CROPPER
              4: AAR AVAILABLE TL8 1205Z-
                 1235Z
              5:
F/SQN/WG:  MAR
G1/TYPAC:  GR1A
G2/TSOR:   02
H/TCL:     BEST
```

ATM DECODE

3.(R) **Para A.** The decode of Para A and its subdivisions are:

A1 details the air request task mission number.

A2 the type of mission.

A3 details the type of sensor to be used.

A4 to A7 detail the tasked targets.

a. Each target is allocated a target/line number, location, description, reporting requirement and the target priority. The first target in the example is task number 567 at position NX790660. It is a Cat 12 with "A" reporting required and is priority 3.

b. **Target Location.** The target location can be given as a BE No, lat/long, UTM or BNG.

c. **Target Description.** Targets are described by the use of Cats.

d. **Target Reporting.** Each target will have a reporting requirement. The requirement will be indicated by one of 4 letters (A, B, C or D) after the target category as shown in Table 11-2B-1:

Code	Items to be reported	Purpose
A	All	New Target
B	As requested (See Note 1)	Target change or detection, or surveillance
C	As requested (See Note 2)	Attack planning or weapons recommendation
D	As requested (See Note 2)	Damage assessment

Note 1. When code B is specified STANAG ringed items will be reported on. Target categories 09, 10, 14, 16 and 17 have no ringed items and so the specific items must be requested when code B is used.

Note 2. When codes C or D are requested, the items to be reported on must be specified.

Table 11-2B-1(R)-Target Reporting Code

e. **Target Priority.** Target priority is indicated by the number 1, 2 or 3. The highest priority is 1. Plan to fly the targets in priority order. TOW/TOD is to be flown in the order dictated by the tasker.

3.(R) **Para B.** Para B specifies the TOT. This TOT refers to the highest priority target. If all the specified targets are of equal priority the TOT applies to the first listed target.

4.(R) **Para C.** Para C gives the position of friendly forces within 1000 metres of any of the targets.

5.(R) **Para D.** Para D details the control arrangements. As the Marham ATM does not have Paras E or J this Para is used to specify the IFREP agency and frequency, and any other information.

6.(R) **Paras E, F and G.** These Paras specify the agency, type and number of aircraft tasked, and the sensors to be used.

VELOCITY / HEIGHT GRAPH

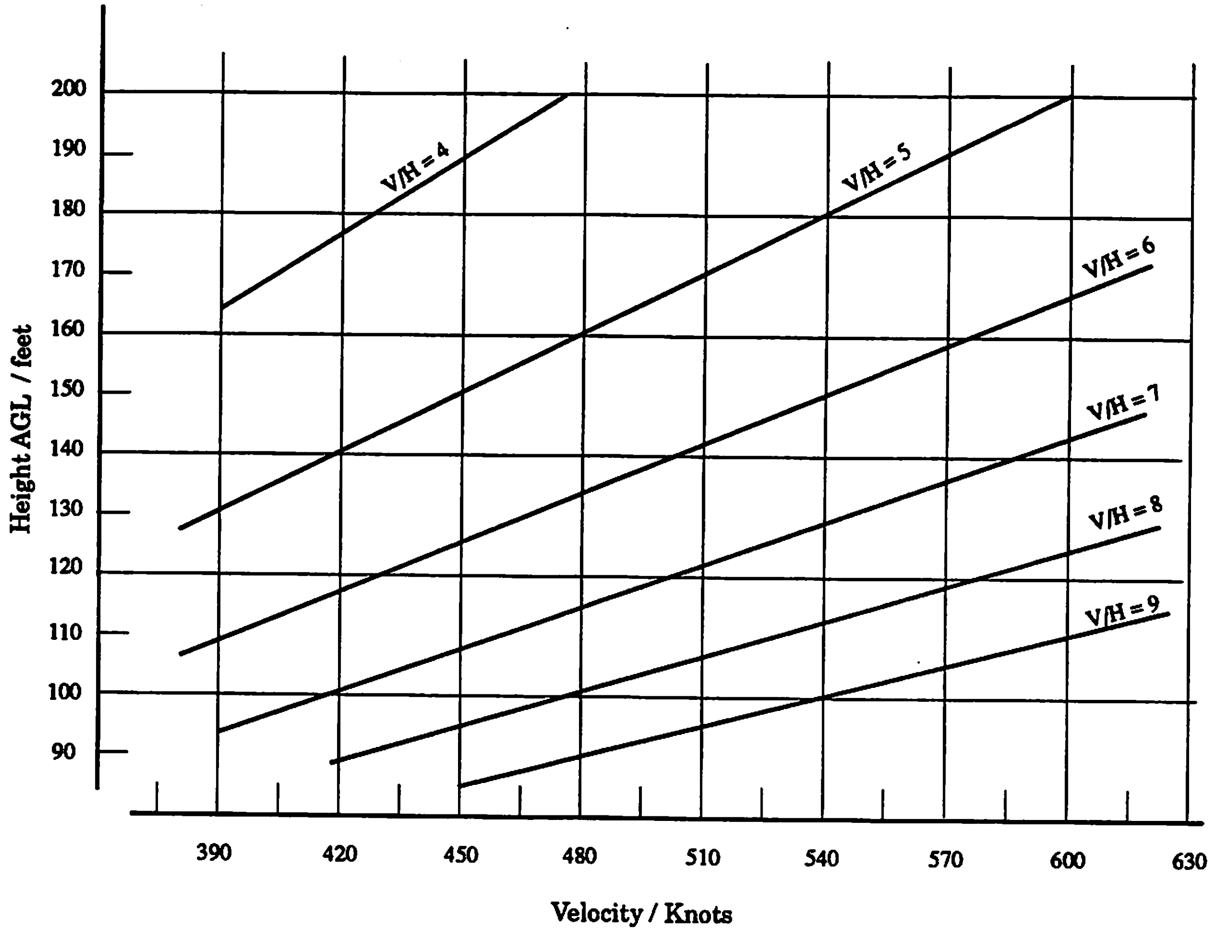


Figure 11-2C-1 (U) - Graph of Velocity v Height (V/H)

INTENTIONALLY BLANK

ANNEX D TO
SECTION 11 CHAPTER 2 OF
TORNADO GR1 TACTICS MANUAL

STRIP AND LINE SEARCH TECHNIQUES

INTRODUCTION

1.(R) The Tornado system is fully compatible with flying both VMC and IMC strip searches. Line searches are fully VMC compatible, but only simple lines can be flown in IMC. As with all IP to target runs the basics still apply. This Annex details the pertinent points specific to line and strip searches.

REQUIREMENTS

2.(R) **Start and End Points.** Strip and line searches will be tasked to start and end at specific points. The first tasked point is always the line start, and the TOT applies to this point. To ensure that the reconnaissance recorders "event" correctly the tasked line/strip start (LS) and line/strip end (LE) points are to be entered into the aircraft system with the appropriate reconnaissance annotations. Neither of these points have to be in the route line but both points should be over-flown.

3.(R) **Area of Interest.** Crews are required to search within 200 metres either side of the strip/line. For a strip/line search, imagery of LS and LE points and significant sightings en-route are required. Aim to get coverage of as much of the line as possible.

PLANNING

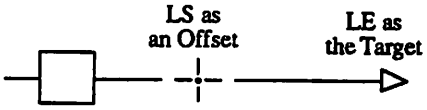
4.(R) **Run-in.** Crews should aim to plan a run-in to the LS point of about 10 nm. This run-in should ideally be on the LOA for strip searches, and approximately on the initial LOA for line searches. Tactical considerations and ground features might dictate planning that will not totally comply with the ideal.

5.(R) **Software Considerations.** When planning line and strip searches bear in mind that with current software, offsets can be a maximum of 20 nm from the target. This might dictate which technique, described below, can be used. Furthermore, recce steering only operates when the system is in the attack routine, a weapons package is not selected and the /STEER information has been entered in the MC.

STRIP SEARCH TECHNIQUES

6.(R) All strip searches are IMC compatible. Either of the 2 techniques described below can be used:

a. **Short Strip.** For lines such as ports, rail yards and airfields that are up to 3 nm long a short strip technique is suitable. The LE is made into the target, with the LS as an offset. For an IMC plan the LS should be on the straight line between the IP and the target. For a VMC plan the offset could be slightly displaced from this line. Only the LE waypoint needs to be in the route line but both points need to have their lat/long in the MC. Reconnaissance steering need only be entered for the LE, and should be the LOA between line start and line end. A diagram of this is at Figure 11-2D-1. Approaching the strip, with the autopilot engaged, and in the attack routine, reconnaissance steering will aim to position the aircraft on planned LOA, which should pass over the LS. It will not steer the aircraft to the LS.



Note. The run-in must be on the extended LOA from LS to LE to be truly IMC compatible.

Figure 11-2D-1(R) - Short Strip Technique

b. **Long Strip.** For strips where the first offset is greater than 20nm from the LE, the Long Strip method should be used, see Figure 11-2D-2. For this technique, both the LS and LE points are made into reconnaissance targets with the offsets being calculated from the LS. The IP must be on the extended line between the LS and LE. Both targets must be in the route line. Reconnaissance steering may be entered for both points. Approaching the strip, with the autopilot engaged, and in the attack routine, reconnaissance steering will aim to position the aircraft on LOA to the LS. Once beyond the LS, the NWAMS target button must be reselected to obtain reconnaissance steering to the LE (consideration should first be given to accepting the error).

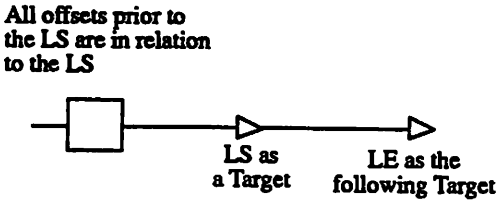

All offsets prior to the LS are in relation to the LS
LS as a Target
LE as the following Target

Figure 11-2D-2(R) - Long Strip Technique

LINE SEARCH TECHNIQUES

7(U). **VMC Planning.** Either of the techniques described above may be used for Day/VMC planning. From the start to the end, the line is flown visually. When any targets are detected, wings level IRLS imagery should be obtained if possible.

8.(R) **IMC Planning.** The run starts with a LS event and finishes with a LE event. Intermediate turning points are calculated so as to give the best coverage using the TFR. The intermediate turning points are then re-plotted 3-4 seconds earlier to allow the TFR to "roll into" the turn. These intermediate points should not be reconnaissance POIs. It should be noted that the aircraft will maintain wings level for 1 nm about the LS, LE and any POIs. The large turning circle of a Tornado, using the TFR, limits the ability to cover tortuous line searches in night/IMC. However, it is possible to fly some straighter line searches and still retain useful coverage at night, but this requires careful planning. For a wiggly line a pair of aircraft with different runs, and time de-confliction, may be required or alternativley it could be flown as two separate portions.

STAND-OFF AND TARGET SCALE

9.(C) In late 1991 a 13 Sqn sortie was flown to provide evidence of target scale and resolution at a variety of aircraft heights and stand-off distances. The results of the 13 Sqn trial sortie are summarised below (some of the figures have been modified using data from more recent sorties):

a. **IRLS Observations.**

(1) Optimum stand-off at any height is always less than 250 metres.

(2) Flying at 200 feet the optimum stand-off is 60-100 metres rising to 75-200 metres when flying at 300-500 feet. Beyond 100m stand-off there is an appreciable loss of resolution until the target falls into SLIR cover, when good scale/resolution resumes.

(3) It can be deduced, therefore, that for area target planning an IRLS swathe of only 400-500 metres is possible. For an area search or area target a pair of aircraft and/or a further pass will be essential. Similarly for a strip or line search a usable IRLS swathe of no more than 200 metres either side of track is the best that you can hope for.

b. **SLIR Observations.** Although the SLIR coverage was not specifically investigated a couple of passes were flown and the following observations were made:

(1) During a 200 ft pass with 500 metres stand-off, and the SLIR ground stabilised, good imagery was produced, but there was a problem with sensor shadow.

(2) As a comparison, a 1,500 ft pass with 20 degrees AOB and approximately 1.5 km stand off, and with the SLIR locked was flown. Sensor shadow was significantly reduced whilst scale was still reasonable.

(3) Therefore for those tasks where a more covert approach in a non-hostile environment is required SLIR pointing is a good option.

RECCE ATTACK INTERFACE (RAI)

1.(U) This Annex details the procedures to be used, and highlights a few of the problems associated with RAI. RAI requires detailed co-ordination to maximise the results. The overall mission leader is always the package commander.

TASKING PROCEDURE

2.(U) Tasking will normally be by an ATM. When planning a non-tasked RAI mission ensure that all the details contained in an ATM are agreed between the participating formations.

3.(R) Air Task Message (ATM). The ATM will use the following format:

a. Callsign and airbase of the interfacing element.

b. Transmission time of RAI.

c. Contact Point for transmission of the air brief.

d. Challenge call by recce element.

e. Transmission frequency (possibly with an alternate).

f. Response call by the attack element.

g. Position reference system and reference position.

h. Target description.

i. Other requirements.

4.(R) **ATM Example.** An example of an ATM tasking an RAI mission is shown below:

RAI 2TM700 MARHAM/0900/MA143068/
KODAK/231.9 ALT 348.75/PANTHER/
TARGET MATRIX LV8387/LOCATE
POINT DEFENCE

CO-ORDINATION

5.(R) **DMPIs and Priorities.** The attack package commander must inform the reconnaissance leader of the target priorities. Using a pre-arranged system or codes the reconnaissance leader will then be able to pass details of any targets found in their priority order.

6.(R) **Alternate Targets.** Attack missions directed to accomplish RAI should be provided with an alternate target to cater for no contact with the reconnaissance aircraft, no targets being found by the reconnaissance aircraft or bad weather in the target area.

7.(R) **Timing.** The minimum interval between the over-flight by recce aircraft and the attack TOT should be at least 5 minutes. Enough time should be allowed for the reconnaissance aircraft to find the target and to transmit the IFREP, and for the attack crew to assimilate the reconnaissance information, to enter the details into their navigation systems and to organise the attack, but not to give the ground positions a time to change. When integrating reconnaissance and attack assets bear in mind that the reconnaissance TOT is for the LS point and the attack TOT is for the target. On long line or strip searches this could result in a confliction.

8.(R) **Position Reporting Reference System.** The DMPI position reference system must be agreed between the reconnaissance and attack leaders. Any system can be devised but it must be simple and concise. Appendix 1 details a number of standard position reporting reference systems.

9.(R) **Air Brief.** To improve the probability of the Air Brief reaching the attack aircraft consideration should be given to radio relay via AWACS, possibly on 2 frequencies to minimise the effects of communications jamming. This technique is known as Autocat.

10.(R) **Contact Point.** The planned position for transmission and reception of the Air Brief should be abeam a recognisable ground feature, preferably in a low threat area and bearing in mind possible terrain screening. Aircraft should aim to fly 180 degrees out, and to the right side of the contact point. On exercise RAI assets have often been targeted by friendly fighters, therefore brief any AD support on procedures.

11.(U) **Suggested RAI Telephone and Air Brief Format.** A suggested briefing format is shown at Table 11-2E-1. (The items in italics may need to be passed in the Air Brief). During Exercise/War, AMSL 1800 should be used if any code-words are passed over in-secure communications, ensuring that the correct code relevant at the time of the telephone conversation is used.

a	**Recce Details** Callsign TOT LOA	
b	**Attack Details** Callsign TOT LOA	
c	**Targeting** *Type Priority and any codewords* *Pop-up codeword*	
d	**Reporting Reference System** Type Origin Orientation Check correct example Co-ordinates of likely DMPIs	
e	**Air Brief** *Challenge call by recce leader* *Response call by attack package* Contact point and heading Time of broadcast Frequencies: Primary: Secondary	

Table 11-2E-1(R) - Co-ordination Briefing Format

RECONNAISSANCE AIRCRAFT PROCEDURES

12.(U) RAI will generally be a Day/VMC procedure, unless the target area is reasonably small and the targets are easily identifiable.

13.(U) **Offsets and Pre-Target Fixing.** Any fix errors evident at the pre-target fix or on the offsets should be accepted and the offset re-marked. This ensures that the MC position and therefore any identified targets are as accurate as possible. It should be noted that this "target mark" facility assumes "flat earth".

14.(R) **Air Brief.** Once the appropriate DMPIs have been identified and prioritised the Air Brief can be passed to the attack package at the Contact Point (CP) and at the pre-briefed time. DMPIs are transmitted using the pre-briefed position reference system, in order of priority, together with any other relevant information. Approaching the CP the reconnaissance aircraft transmit their codeword callsign, and wait for the attack package reply codeword. The reconnaissance aircraft then pass the Air Brief. Once the attack package have received the Air Brief they acknowledge.

ATTACK AIRCRAFT PROCEDURES

15.(R) Most targets will require CBU, or less likely, lofted air-burst 1000lb bombs. This simplifies over-target separation. A number of IPs can be planned as accurate fix points, together with an accurate fix point in the immediate target area. Depending on the position reference system used, the targets can then be attacked in a number of ways.

16.(R) **Bullseye.** The simplest technique, which only works in Day/VMC, is to use the Bullseye system - see Appendix 1. The Bullseye is "crunched" as a target position, and is preferably radar significant. The IP is then "crunched" as an all sensor offset in the normal fashion, together with a second offset if required. The DMPI position, passed as a range and bearing from the Bullseye is then inserted directly as a range and bearing offset as "3V". The pilot then flies to the "3V" offset. Approaching "3V", and once the pilot has identified the target, he selects TOO with an active sensor to carry out the attack. The attack aircraft should also have the Bullseye range and bearing grid marked on their target maps, in order that the target can be plotted for target area familiarisation.

17.(R) **GEOREF or UTM.** The GEOREF or UTM technique is suitable in any meteorological condition. The DMPI is passed as an UTM which can then be directly entered into the MC as a target. Note that in the UK TIRRS gives BNG. This can be passed for plotting purposes, but a Lat/Long is also required to insert into the MC. The IP and a radar significant fix point in the immediate target area are "crunched" as accurate Lat/Longs. From this stage there are 2 methods of carrying out an attack:

a. **Method 1.** Approaching the IP, pre-bomb fix is selected to enable 100% of the fix errors to be carried to the target. The point is then fixed in either Phase 1, 2, 3 or OTF, and the error is accepted. Re-steer to the target and the pilot follows the HSI/HUD track bug towards the target. The navigator then re-fixes on the fix in the target area until approximately 25 seconds or 3 nm to go to the target. After accepting the fix errors, "Target" is selected on the NWAMS and the attack is completed in the normal fashion. This method aims to minimise point drift between the last fix and bomb release.

b. **Method 2.** Using the range and bearing facility in the MC, the range and bearing is calculated between the DMPI and the fix point in the target area. If time permits this process is repeated for the IP. These range and bearings are noted down and then inserted into the MC as range and bearing offsets. Ensure that the bearing is from the DMPI to the IP/fix point by checking that the offset values are in the correct sense. Approaching the IP, the MC is updated as a fix or offset. Approaching the target, the system is further updated from the near to target offset, and the attack is completed in the normal fashion. This attack is night/IMC compatible and offers potentially the greatest accuracy but it requires a lot of "heads in" time for the navigator and there is scope for error in the offset calculations.

INTENTIONALLY BLANK

APPENDIX 1 TO ANNEX E TO
SECTION 11 CHAPTER 2 OF
TORNADO GR1 TACTICS MANUAL

POSITION REPORTING REFERENCE SYSTEMS

1.(U) This Appendix details some of the more common position reporting reference systems. These can be adapted to meet the needs of a particular sortie but bear in mind that during war communications can be disrupted, and will probably be insecure.

2.(R) **Bullseye.** The position of activity is reported using range and bearing from a defined point. Ideally the Bullseye is a radar significant point. Range is reported in nm, and bearing is relative to True North. For Tornado use, reported positions should be given to one decimal place of degrees and 2 decimal places for range.

3.(R) **Known Possible Locations.** Some targets will be known to exist only at fixed locations. These locations can be accurately "crunched" as possible target positions and given either numbers, letters or codewords. The reconnaissance aircraft will then pass only the active areas in target priority. An example is shown in Figure 11-2E1-1 where the target area has been divided into 6 areas (they do not have to be regular), labelled A to F. Priority 1 is MBTs, 2 is APCs and 3 is SSVs. The reconnaissance aircraft detects MBTs in area F and SSVs in area B. It would be reported as in it's simplest form as "......F and B". If time and communications allow, the report could be expanded to let the attack aircraft to know what types are in each area but the prime objective is to allow the attack package to know concisely which areas, in priority, are "hot".

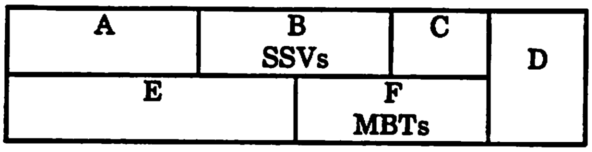
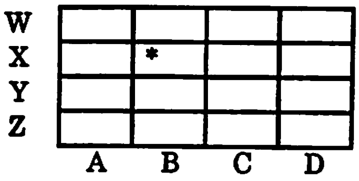


Figure 11-2E1-1(U) - Target Area Location Reporting System

4.(R) **Target Matrix.** The matrix system uses 1 km squares that are orientated North/South along the Grid squares. Squares are labelled A to M on the West/East axis and Z to N on the South/North axis (see Figure 11-2E1-2). Reporting accuracy may be further improved by dividing the 1 km squares into tenths. The reference point (RP) is in the South-West corner and is defined by 2 letters and 4 figures. e.g. NA 1234.

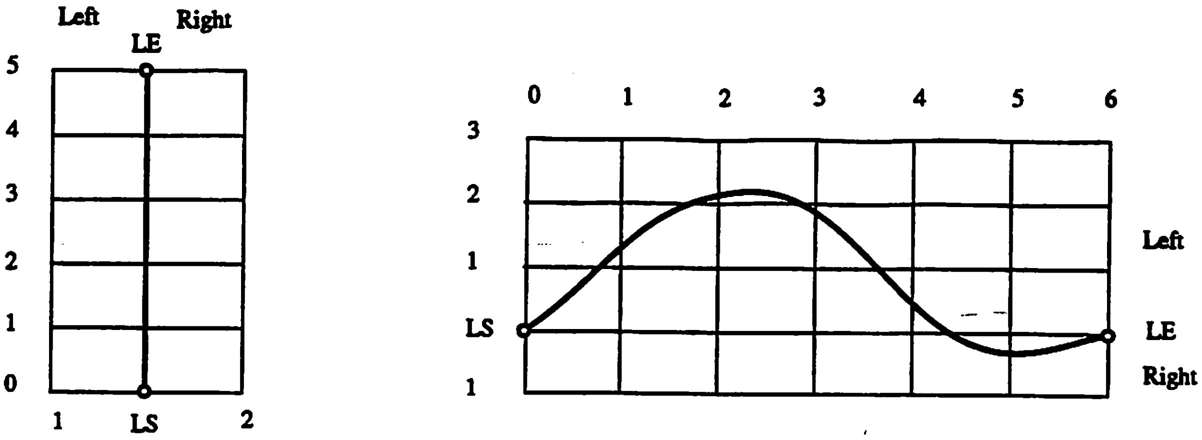


Example: * is at BX28

Figure 11-2E1-2(R) - Target Matrix Reporting System

5.(R) **Line Thrust System.** The Line Thrust system uses 1 km squares orientated along a line directly between the start and end points of strip and line searches - see Figure 11-2E1-3. Zero point is at the Line Start (LS). Reporting accuracy may be further improved by dividing the 1 km squares into tenths.

Text continues overleaf



Strip Search

Line Search

Figure 11-2E2-3(R) - Line Thrust Reporting System

6.(R) **UTM Grid.** Target positions may be reported using UTM, omitting the 2 letters. The GR1A uses BNG in the UK. BNG cannot be entered directly into the MC but a Lat/Long can be obtained and then GEOREF can be used.

7.(R) **GEOREF.** GEOREF positions may be reported using the 2 letter identifier in the lower left corner of each one degree grid on air navigation charts, followed by minutes of longitude then latitude. The general location of the target is usually known so the 2 letter identifier can be omitted.

RECONNAISSANCE STEERING LAWS

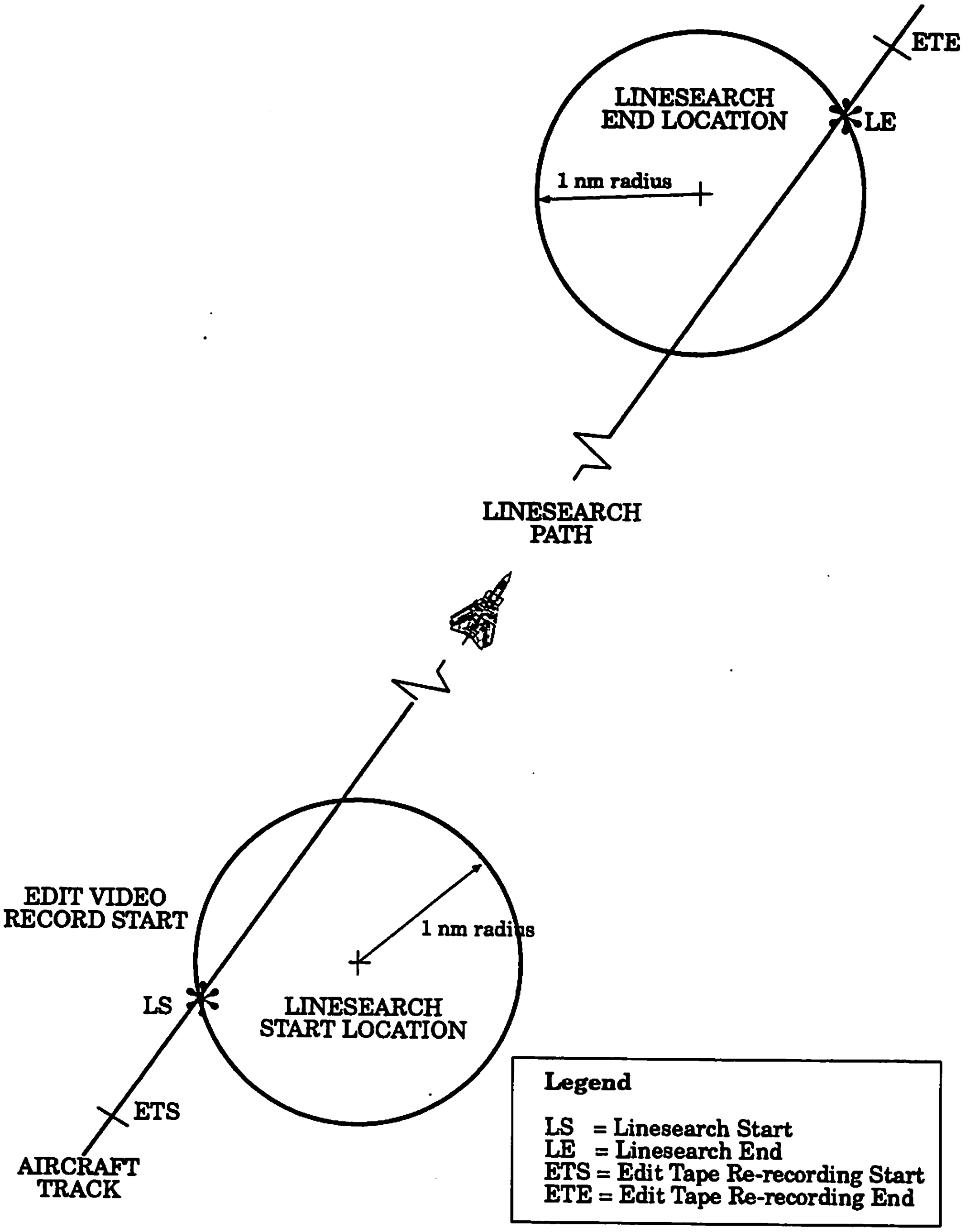
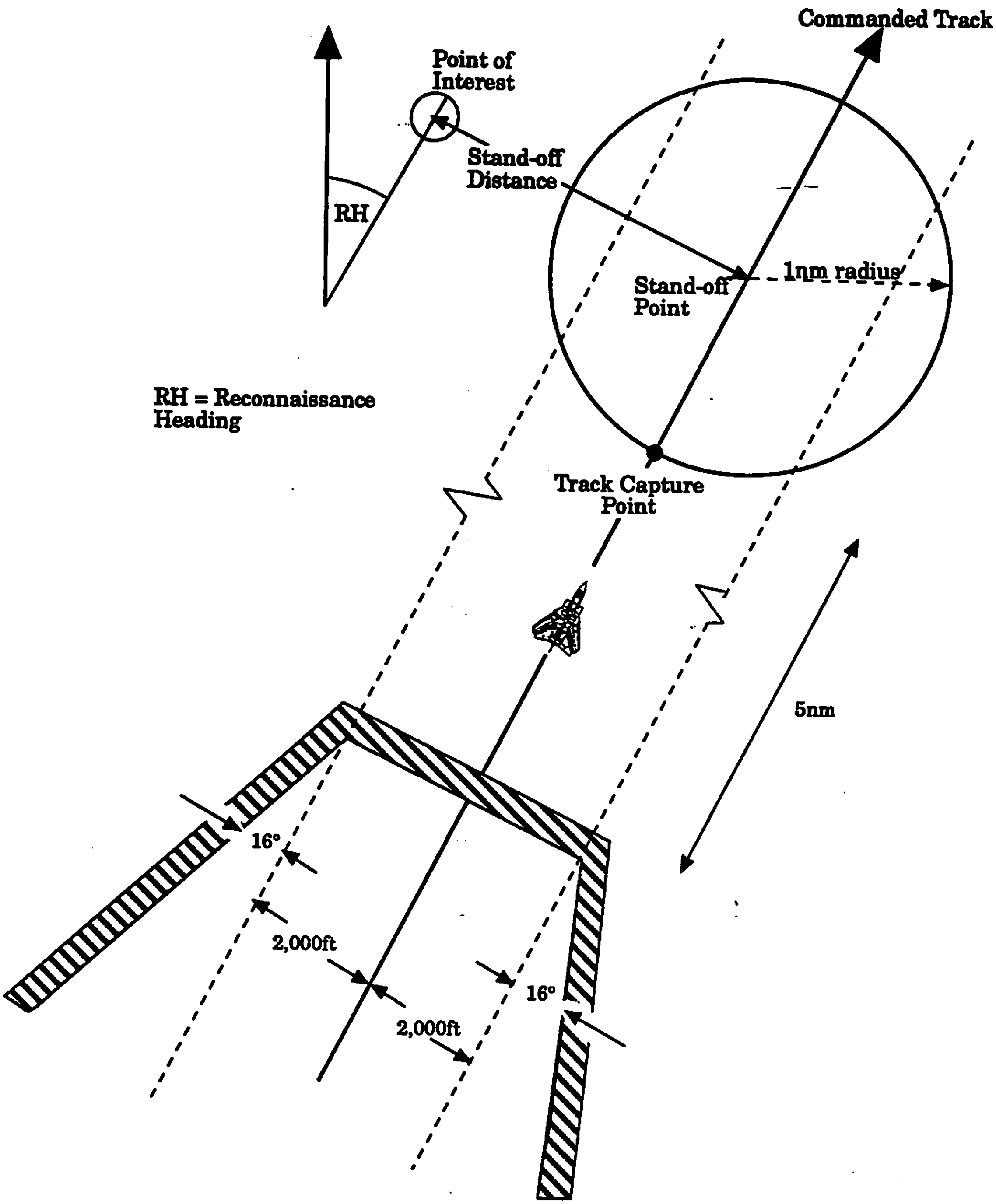


Figure 11-2F-1 (R) - Automatic Linesearch Flight Parameters



Groundspeed (knots)	Funnel Angle (deg)
400	22.1
420	21.0
450	19.6
480	18.4
500	17.6
550	16.0
600	14.7

Note:

The Funnel angle varies with aircraft speed. It is 16° at 550kn and 30° at 300kn. The angle can be calculated from the following equation:

Angle = 14896 / Vel. along Track (in ft.sec^{-1})

Figure 11-2F-2 (R) - Flight Steering Parameters

PART C

A/C	SORTIE	CREW	MSN No	DATE
A		KNI/BAR	2T 123	1 APR 91

TGT DETAILS	CAT	TOT	EVENT	PRIORITY SENSOR			TARWI
		HR MIN SEC	No TYPE	L	V	R	
LATTICE MAST 4xWX COVERED M / WAVE RELAY	03A	10 45 01	10 AU		✓	X	8481X
SN 268311	04B	11 00 02	11 P1	✓			6631X
MIL CONVOY	06A	11 15 05	20 LS		✓		0081X

CDIRRS FAULTS: REMARKS:	ENG OFF	1200 Z
RT SLIR FAIL PRE-TGT 1		

Notes:

1. "Sortie" completed by the RIC.
2. "X" denotes sensor failure.
3. EOT is the last to be completed - either at engine off, or hot sensor download.
4. Part C accompanies maps/CVR to RIC.

INTENTIONALLY BLANK

Section 12

Glossary

CHAPTER 1 - CODEWORDS AND ABBREVIATIONS

A.

AAA	-	Anti-Aircraft Artillery
AAM	-	Air-to-Air Missile
AARCTM	-	Air-to-Air Refuelling Combined Task Message
ACA	-	Airspace Co-ordination Area
ACM	-	Air Combat Manoeuvre(ing)
ACO	-	Airspace Co-ordination Order
AD	-	Air Defence
ADI	-	Attitude Direction Indicator
ADOPS	-	Air Defence Operating Procedures
ADU	-	Air Defence Unit
AFD	-	Air Force Department
AFDS	-	Automatic Flight Director System, Autopilot and Flight Director System
AFV	-	Armoured Fighting Vehicle
AGR	-	Air-to-Ground Ranging
AGL	-	Above Ground Level
AI	-	Air Interception/Air Interdiction
AMSL	-	Above Mean Sea Level
AOA	-	Amphibious Objective Area (Maritime)/ Angle of Attack
AOJ	-	Angle -on-Jam (radar)
APHE	-	Armour Piercing High Explosive (Projectile)
APU	-	Auxiliary Power Unit, Automatic Pull-Up
APC	-	Armoured Personnel Carrier
AR	-	Air Route (Airspace Management)
ARB	-	Attack Release Button
ARD	-	Advanced Radar Display (Digital)
ARS	-	Area Reference System
ASO	-	Automatic Steering Override
ASOC	-	Air Support Operations Centre
ASP	-	Aircraft Servicing Platform (RAMP)
ASR	-	Air Staff Requirement
ASUW	-	Anti-Surface Warfare
ATF	-	Automatic Terrain Follow
ATL	-	Above Target Level
ATM	-	Air Task Message
ATO	-	Air Task Order
ATTG	-	Automated Tactic Target Graphic
AUW(M)	-	All-Up Weight (or Mass)
A W	-	Automatic Weapons

B.

BAI	-	Battlefield Air Interdiction
BDZ	-	Base Defence Zone (Airspace Management)
BITE	-	Built In Test Equipment
BRST	-	Boresight (Weapon Mode)
BUSTER	-	An Action Radio Call meaning 'Select Maximum Continuous Power/Speed'

C.

CA	-	Counter Air/Combat Available
CADA	-	Co-ordinated Air Defence Area (Maritime)
CAP	-	Combat Air Patrol
CAS	-	Close Air Support
CBU	-	Cluster Bomb Unit

CCIL - Continuously Computed Impact Line
CCIP - Continuously Computed Impact Point
CFD - Chaff and Flare Dispenser
CG - Command Guidance
CHOP (FREQUENCY) - Change of Frequency (Radio Call)
CL - Co-ordination Level/Conventional Load (Wpn Tasking)
CLAPU - Closed Loop Automatic Pull-Up
CMJ - Co-oerative Modulated Jamming
CPGS - Cassette Preparation Ground Station
CR - Central Region/Combat Ready
CRAM - Clearance Range Ahead Monitor (TF)
CRPMD - Combined Radar and Projected Map Display
CRT - Cathode Ray Tube
CTPD - Conventional Target Planning Document
CVR - Cockpit Voice Recorder
CW - Continuous Wave
CWEM - Conventioal Weapon Employment Manual
CWP - Central Warning Panel/Contractors Working Party

D.

DMPI - Desired Mean Point of Impact
DOO - Daily Operations Order

E.

ECCM - Electronic Counter Counter Measures
ECM - Electronic Counter Measures
EESD - Enhanced E-Scope Display
EJ - Escort Jamming
EMCON - Emission Control
EMP - Electromagnetic Pulse
EO - Electro Optical
ESM - Electronic Surveillance Measures
EW - Electronic Warfare

F.

FAC - Forward Air Controller
FCR - Fire Control Radar
FCZ - Forward Combat Zone
FD - Flight Director
FEBA - Forward Edge of the Battle Area
FF - Free-Fall
FLIR - Forward Looking Infra-Red
FLOT - Forward Line Own Troops
FOV - Field of View
FP - Flight Path
FSCL - Fire Support Co-ordination Line

G.

GA	-	Ground Alert/General Alert
GBJ	-	Ground-based Jammer
GCI	-	Ground Controlled Interception (Radar)
GMR	-	Ground Mapping Radar
G/S	-	Groundspeed

H.

HAFEZ	-	Hostile Aircraft Free Engagement Zone (Air Defence)
HIDACZ	-	High Density Airspace Control Zone
HAS	-	Hardened Aircraft Shelter
HDD	-	Head-Down Display
HE	-	High Explosive
HEL	-	Hunting Engineering Ltd
HOJ	-	Home on Jam (weapon)
HUD	-	Head-Up Display
HVU	-	High Value Unit (Maritime target)

I.

ICAN	-	International Convention of Aeronautics and Navigation
ICO	-	Instinctive Cut-Out
IFREP	-	In-Flight Report
II	-	Image Intensifiers
IN	-	Inertial (Navigator)
INCDU	-	Inertial Control and Display Unit
IOCA	-	Initial Offensive Counter Air
IP	-	Inertial Point
IR	-	Infra-Red
IRD	-	Infra-Red Decoy
ISA	-	International Standard Atmosphere
IWR	-	Infra-Red Warning Receiver

J.

K.

KCAS	-	Knots Calibrated Air Speed
KF	-	Kalman Filter
KNICKERS	-	Action Radio Call for Release of Retard Bomb for Self-Defence

L.

LFD	-	Longitudinal Flight Datum
LGB	-	Laser Guided Bomb
LLTR	-	Low Level Transit Route
LSDW	-	Laser System Damage Weapons
LSW	-	Laser Warning Receiver
LYRE BIRD	-	Audio Warning System

M.

MACA	-	Maritime Air Co-ordination Area
MACT	-	Manoeuvring Air Combat Training
MASS	-	Maritime Air Surface Surveillance
MAWR	-	Missile Aproach Warning Receiver
MAE	-	Mean Area of Effect
MAW	-	Missile Approach Warner
MC	-	Main Computer

MESH - Minimum En-route Safety Height
MFBF - Multi Function Bomb Fuze
MISREP - Mission Report
MM - Manoeuvre Monitor (TF system)
MOB - Main Operating Base
MPA - Maritme Patrol Aircraft
MRCP - Main Radar Control Panel
MRI - Monopulse Resolution Improvement
MSD - Minimum Separation Distance
MSA - Minimum Safe Altitude
MSDS - Marconi Space Defence Systems
MSJ - Multiple Source Jamming

N.

NATO - North Atlantic Treaty Organization
NBC - Nuclear, Biological and Chemical (weapon/ procedures)
nm - Nautical Mile
NVG - Night Vision Goggles
NWAMS - Navigator Weapon, Aiming Mode Selector

O.

OAS - Offensive Air Support
OCA - Offensive Counter Air
OLAPU - Open Loop Automatic Pull-Up
OOA - Out of Area (Operations)
OTF - On-Top Fix

P.

PAT - Preferred Approach Track
PCL - Preferred Conventional Load (Wpn tasking)
PFM - Pre-flight Message (Computer)
PHASE 1 - Navigator Fix Using Main Sensors
PHASE 2 - Pilot Fix Using Visual or Laser Inputs
PP - Present Position

Q.

QA - Quality Assurance
QRA - Quick Reaction Alert

R.

RAM - Radar Absorbent Material
RCS - Radar Cross Section (of radar target)
RDE - Rapid Data Entry
REC - Radar Electronic Combat
RHH - Radar Height Hold
RHWR - Radar Homing and Warning Receiver
RIPL - Reconnaissance and Interdiction Planning Line
ROL - Read Out line (on TV Tab)
ROZ - Restricted Operations Zone
RPMD - Repeater Projected Map Display
RTB - Return to Base
RV - Rendezvous
RWE - Radar Warning Equipment
RWR - Radar Warning Receiver

S.

SAG - Surface (Soviet) Action Group
SAHR(S) - Secondary Attitude and Heading Reference (System)
SAM - Surface-to-Air Missile
SAP - Simulated Attack Profile
SC - Special Corridor (Airspace management)
SCH - Set Clearance Height
SCL - Standard Conventional Load (Weapon tasking)
SE - Special Eject (BOZ)
SEAD - Suppression of Enemy Air Defences
SEP - Specific Excess Power (Aircraft performance)
SFCO - Stick Force Cut-Out
SHORAD - Short Range Air Defence (Engagement Zone)
SIGINT - Signals Intelligence
SM - Sub-Munition (JP233)
SMS - Stores Management System
SNOWCAT - Support of Nuclear Operations with Conventional Air Tasking
SOJ - Stand-Off Jamming
SPJ - Self Protection Jamming
SSM - Surface to Surface Missile
SSPK - Single Shot Probability of Kill

T.

TA - Terrain Avoidance
TACDI - Tactical Direction (Attack support)
TACP - Tactical Air Control Party
TAR - Tactical Air Reconnaissance
TC - Transit Corridor (Airspace management)
TF - Terrain Follow
TFR - Terrain Following Radar
TI - Thermal Imagers
TL - Traverse Level (Airspace management)
TMMR - Temporary Minimum Risk Route(Airspace management)
TOO - Target of Opportunity
TOT - Time On (Over) Target
TPF - Target Planning Folder
TWP - Threat Warning Panel

U.

UV - Ultra Violet

V.

VDU	-	Visual Display Unit
VRP	-	Visual Reconnaissance Probe (aircraft)

W.

WAMS	-	Weapon Aiming and Mode Selector
WFZ	-	Weapons Free Zone
WP	-	Warsaw Pact

X.

Y.

Z.

ZLC	-	Zero Command Line (TF)

List of Effective Pages

TORNADO GR1 TACTICS MANUAL

LIST OF EFFECTIVE PAGES

1. The printed Amendment Number appearing on a page indicates when the sheet was issued and does not necessarily imply an alteration to the text on that side of the sheet.

2. Pages that have been amended in manuscript are marked "(MS)" after the relevant AL No. Some pages are Intentionally Blank: these are annotated "(IB)". Sheets which contain a caveat are marked accordingly: "S", "C" and "R" should be read as UK SECRET, UK CONFIDENTIAL etc.

Page / Backed by	Security Grading	Issue AL
Title Page/Security Warnings	S UK B	AL 2
Prelim Pages		
1/2(IB)	U	Original
3/4(IB)	U	AL 2
5/6(IB)	U	Original
x TAC MEMO 2 (MS) 7/8	U	* - ~~AL 3~~ ~~TAC MEMO 1 (MS)~~
x TAC MEMO 1 (MS) 9/10(IB)	U	* - ~~AL 3~~
11/12	U	Original
13/14	U	Original
15/16(IB)	U	Original
Amendment List Instructions	R	AL 3
SECTION 1		
Marker Card (Reverse IB)	U	Original
Chapter 1		
1-1-1/1-1-2	C	Original
1-1A-1/1-1A-2	SUKB	AL 2
1-1A-3/1-1A-4	SUKB	AL 2
1-1A-5/1-1A-6	SUKB	AL 2
1-1A-7/1-1A-8(IB)	SUK B	AL 2
1-1A-9/1-1A-10(IB)	R	AL 2
SECTION 2		
Marker Card/ (Reverse IB)	U	Original
Section Contents		
2-SI-1/2-SI-2	R	Original
Chapter 1		
2-1-1/2-1-2	S	Original
2-1-3/2-1-4	S	AL 2(MS)
2-1-5/2-1-6	S	AL 2(MS)
2-1-7/2-1-8	S	AL 2(MS)
2-1-9/2-1-10	S	AL 1
2-1-11/2-1-12(IB)	C	Original
Chapter 2		
2-2-1/2-2-2	S	AL 2(MS)
2-2-3/2-2-4(IB)	C	Original
SECTION 3		
Marker Card/ (Reverse IB)	U	Original
Section Contents		
3-SI-1/3-SI-2(IB)	R	Original
Chapter 1		
3-1-1/3-1-2	S	AL 2
Chapter 2		
3-2-1/3-2-2	S	AL 2
SECTION 4		
Marker Card/ (Reverse IB)	U	Original
Section Contents		
4-SI-1/4-SI-2	R	Original
4-SI-3/4-SI-4(IB)	R	Original

TAC MEMO 2 (MS)
~~AL 3~~

INTENTIONALLY BLANK

Chapter 1		
4-1-3AM/4-1-3BM	S	TECMEMO1 (MS)
4-1-1/4-1-2	S	AL 2
4-1-3/4-1-4	S	AL 2
4-1-5/4-1-6	S	AL 2
Chapter 2		
4-2-1/4-2-2	S	Original
4-2-3/4-2-4	S	Original
4-2-5/4-2-6	S	AL 1 (MS)
4-2-7/4-2-8(IB)	S	Original
Chapter 3		
4-3-1/4-3-2	S	Original
4-3-3/4-3-4	S	AL 2
4-3-5/4-3-6(IB)	S	Original
Chapter 4		
4-4-1/4-4-2	S	AL 2
4-4-3/4-4-4(IB)	R	AL 2
Chapter 5		
4-5-1/4-5-2(IB)	S	Original
Chapter 6		
4-6-1/4-6-2	S	Original
4-6-3/4-6-4	S	Original
4-6-5/4-6-6	SUKB	Original
4-6A-1/4-6A-2(IB)	R	Original
SECTION 5		
Marker Card/ (Reverse IB)	U	Original
Section Contents		
5-SI-1/5-SI-2	R	Original
5-SI-3/5-SI-4	R	Original
5-SI-5/5-SI-6	R	Original
5-SI-7/5-SI-8	R	Original
Chapter 1		
5-1-1/5-1-2	S	Original
5-1-3/5-1-4	S	Original
5-1-5/5-1-6	S	Original
5-1-7/5-1-8(IB)	R	Original
5-1A-1/5-1A-2(IB)	R	Original
5-1B-1/5-1B-2(IB)	C	Original
5-1C-1/5-1C-2	S	Original
5-1D-1/5-1D-2(IB)	S	Original
Chapter 2		
5-2-1/5-2-2	S	Original
5-2-3/5-2-4	S	Original

5-2-5/5-2-6	S	AL 2(MS)
5-2-7/5-2-8	S	Original
5-2-9/5-2-10	S	Original
5-2-11/5-2-12	S	Original
5-2-13/5-2-14	C	AL 2(MS)
5-2-15/5-2-16	C	Original
5-2-17/5-2-18(IB)	C	Original
5-2A-1/5-2A-2(IB)	R	Original
5-2B-1/5-2B-2(IB)	C	Original
5-2C-1/5-2C-2	C	Original
5-2D-1/5-2D-2	C	Original
5-2E-1/5-2E-2	C	Original
5-2E-3/5-2E-4(IB)	C	Original
5-2F-1/5-2F-2	S	Original
5-2G-1/5-2G-2	S	Original
5-2H-1/5-2H-2(IB)	C	Original
5-2I-1/5-2I-2	S	AL 2(MS)
Chapter 3		
5-3-1/5-3-2	C	Original
5-3-3/5-3-4	C	Original
5-3A-1/5-3A-2	C	Original
5-3B-1/5-3B-2	S	Original
5-3C-1/5-3C-2(IB)	R	Original
5-3C-3/Transparency	R	Original
5-3C-4/Transparency	R	Original
5-3C-5/Single sided	S	Original
5-3C-6/Single sided	S	Original
5-3C-7/Single sided	S - Caveat	Original
5-3C-8/Single sided	S	Original
5-3C-9/Single sided	S	Original
5-3C-10/Single sided	S	Original
5-3C-11/Single sided	S - Caveat	Original
5-3C-12/Single sided	S	Original
5-3C-13/Single sided	C	Original
Chapter 4		
5-4-1/5-4-2	C	Original
5-4-3/5-4-4	C	AL 2(MS)
5-4-5/5-4-6(IB)	S	Original
Chapter 5		
5-5-1/5-5-2	C	AL 2(MS)
5-5-3/5-5-4	C	Original
5-5-5/5-5-6	C	AL 2(MS)
5-5-7/5-5-8	C	AL 2
5-5-9/5-5-10	C	AL 2
5-5-11/5-5-12	C	AL 2
5-5-13/5-5-14	C	AL 2
5-5-15/5-5-16	C	AL 2
5-5-17/5-5-18	S	Original
5-5A-1/5-5A-2	R	AL 2
5-5B-1/5-5B-2(IB)	R	Original
5-5C-1/5-5C-2(IB)	R	Original
5-5D-1/5-5D-2(IB)	R	Original
5-5E-1/5-5E-2(IB)	R	Original

INTENTIONALLY BLANK

Chapter 6		
5-6-1/5-6-2	C	Original
5-6-3/5-6-4	C	Original
5-6-5/5-6-6	C	AL 2(MS)
5-6-7/5-6-8(IB)	R	Original
Chapter 7		
5-7-1/5-7-2(IB)	R	Original
5-7A-1/5-7A-2(IB)	R	Original
5-7B-1/5-7B-2(IB)	R	Original
5-7C-1/5-7C-2	R	Original
5-7C-3/5-7C-4	R	Original
Chapter 8		
5-8-1/5-8-2	C	AL 2
5-8-3/5-8-4	R	Original
5-8-5/5-8-6	R	Original
5-8-7/5-8-8	R	Original
5-8-9/5-8-10	R	AL 2(MS)
5-8A-1/5-8A-2	R	Original
5-8A-3/5-8A-4	R	Original
SECTION 6		
Marker Card/ (Reverse IB)	U	Original
Section Contents		
6-SI-1/6-SI-2	R	Original
6-SI-3/6-SI-4	R	Original
6-SI-5/6-SI-6(IB)	R	Original
Chapter 1		
6-1-1/6-1-2	C	AL 2
6-1-3/6-1-4	S	AL 2
Chapter 2		
6-2-1/6-2-2	S	Original
6-2-3/6-2-4	S	Original
6-2-5/6-2-6	S	AL 2
6-2-7/6-2-8	S	AL 2
6-2-9/6-2-10	S	Original
6-2-11/6-2-12	C	Original
6-2-13/6-2-14	C	Original
6-2-15/6-2-16	C	Original
6-2-17/6-2-18	C	Original
6-2-19/6-2-20	S	Original
6-2-21/6-2-22	S	AL 2
6-2A-1/6-2A-2	S	AL 2(MS)
6-2A-3/6-2A-4	S	Original
6-2A-5/6-2A-6	S	Original
6-2A-7/6-2A-8	S	Original
6-2A-9/6-2A-10	S	Original
6-2-10AM/6-2-10BM	**C**	**Tac Memo 2(MS**
6-2-10CM/6-2-10DM	**C**	**Tac Memo 2(MS**
6-2-10EM/6-2-10FM	**C**	**Tac Memo 2(MS**
6-2-10GM/6-2-10HM	**C**	**Tac Memo 2(MS**
Chapter 3		
6-3-1/6-3-2	S	Original
6-3-3/6-3-4	S	AL 2
6-3-5/6-3-6(IB)	S	Original
6-3A-1/6-3A-2	C	AL 2
6-3A-3/6-3A-4	C	AL 2
6-3A-5/6-3A-6	C	AL 2
6-3A-7/6-3A-8	C	AL 2(MS)
6-3A-9/6-3A-10(IB)	C	Original
6-3B-1/6-3B-2	R	AL 2
6-3B-3/6-3B-4	C	AL 2
6-3B-5/6-3B-6(IB)	C	Original
6-3C-1/6-3C-2	R	AL 2
SECTION 7		
Marker Card/ (Reverse IB)	U	Original
Section Contents		
7-SI-1/7-SI-2(IB)	R	Original
Chapter 1		
7-1-1/7-1-2	S	AL 2
SECTION 8		
Marker Card/ (Reverse IB)	U	Original
Section Contents		
8-SI-1/8-SI-2	R	Original
8-SI-3/8-SI-4	R	Original
Chapter 1		
8-1-1/8-1-2	S	Original
8-1A-1/8-1A-2	S	Original
8-1A-3/8-1A-4	S	Original
8-1A-5/8-1A-6(IB)	S	Original
8-1B-1/8-1B-2(IB)	S	Original
8-1C-1/8-1C-2(IB)	R	Original
8-1D-1/8-1D-2(IB)	R	Original
Chapter 2		
8-2-1/8-2-2	S	Original
8-2-3/8-2-4	S	Original
Chapter 3		
8-3-1/8-3-2	C	Original
8-3-3/8-3-4	C	Original
8-3-5/8-3-6	C	Original
8-3-7/8-3-8	C	Original
8-3-9/8-3-10(IB)	C	Original

INTENTIONALLY BLANK

8-3A-1/8-3A-2	C	Original
8-3A1-1/8-3A1-2	C	Original
8-3A1-3/8-3A1-4	C	Original
8-3A1-5/8-3A1-6	C	Original
8-3A1-7/8-3A1-8(IB)	C	Original
8-3A2-1/8-3A2-2	C	Original
8-3A3-1/8-3A3-2	C	Original
8-3B-1/8-3B-2	C	Original
Chapter 4		
8-4-1/8-4-2(IB)	U	Original
Chapter 5		
8-5-1/8-5-2(IB)	U	Original
Chapter 6		
8-6-1/8-6-2	S	Original
8-6-3/8-6-4	SUKB	Original
8-6-5/8-6-6(IB)	S	Original
Chapter 7		
8-7-1/8-7-2	C	Original
SECTION 9		
Marker Card/ (Reverse IB)	U	Original
Section Contents		
9-SI-1/9-SI-2	R	AL 2(MS)
9-SI-3/9-SI-4	R	AL 2(MS)
9-SI-5/9-SI-6(IB)	R	Original
Chapter 1		
9-1-1/9-1-2	C	Original
9-1-3/9-1-4	C	Original
9-1-5/9-1-6(IB)	C	AL 2(MS)
9-1A-1/9-1A-2	S	AL 2
9-1A-3/9-1A-4	S	Original
9-1B-1/9-1B-2(IB)	S	Original
Chapter 2		
9-2-1/9-2-2	S	Original
9-2-3/9-2-4	S	Original
9-2A-1/9-2A-2	C	Original
9-2A-3/9-2A-4	C	Original
Chapter 3		
9-3-1/9-3-2	C	Original
9-3-3/9-3-4	S	Original
9-3-5/9-3-6	S	Original
9-3-7/9-3-8	S	Original
9-3-9/9-3-10(IB)	S	Original
9-3A-1/9-3A-2(IB)	R	Original
9-3B-1/9-3B-2	C	Original
9-3C-1/9-3C-2(IB)	R	Original
9-3D-1/9-3D-2	R	Original
9-3D-3/9-3D-4	C	Original
Chapter 4		
9-4-1/9-4-2	C	Original
9-4-3/9-4-4	C	Original
9-4-5/9-4-6(IB)	C	Original
9-4A-1/9-4A-2(IB)	R	Original
SECTION 10		
Marker Card/ (Reverse IB)	U	AL 3
Chapter 1		
10-1-1/10-1-2(IB)	U	AL 3
Chapter 2		
10-2-1/10-2-2	SUKB	AL 3
10-2-3/10-2-4(IB)	R	AL 3
Chapter 3		
10-3-1/10-3-2	SUKB	AL 3
10-3-3/10-3-4	SUKB	AL 3
10-3A-1/10-3A-2	R	AL 3
SECTION 11		
Marker Card/ (Reverse IB)	U	AL 2
Section Contents		
11-SI-1/11-SI-2	R	AL 2
Chapter 1		
11-1-1/11-1-2(IB)	U	AL 2
11-1A-1/11-1A-2(IB)	U	AL 2
Chapter 2		
11-2-1/11-2-2	R	AL 2
11-2-3/11-2-4	R	AL 2
11-2-5/11-2-6	R	AL 2
11-2A-1/11-2A-2(IB)	C	AL 2
11-2B-1/11-2B-2	R	AL 2
11-2C-1/11-2C-2(IB)	U	AL 2
11-2D-1/11-2D-2	C	AL 2
11-2E-1/11-2E-2	R	AL 2
11-2E-3/11-2E-4(IB)	R	AL 2
11-2E1-1/11-2E1-2	R	AL 2
11-2F-1/11-2F-2	R	AL 2
11-2G-1/11-2G-2(IB)	U	AL 3(MS)
SECTION 12		
Marker Card/ (Reverse IB)	U	Original
Chapter 1		
12-1-1/12-1-2	U	Original
12-1-3/12-1-4	U	Original
12-1-5/12-1-6	U	Original
LIST OF EFFECTIVE PAGES		
Marker Card/ (Reverse IB)	U	Original

INTENTIONALLY BLANK

LEP - 1/LEP - 2(IB)	U	~~AL 3~~ TacMemo2(ms)
LEP - 3/LEP - 4(IB)	U	AL 3
LEP - 5/LEP - 6(IB)	U	~~AL 3~~ TAC MEMO 2(ms)
LEP - 7/LEP - 8(IB)	U	AL 3
LEP - 9/LEP - 10 (IB)	U	~~AL3~~ TAC MEMO 2(MS)
Rear Cover		
(IB)/Security Cover	S UKB	AL 2

INTENTIONALLY BLANK